APPLICATION OF ISDN D CHANNEL FOR TELEACTION TELESERVICES

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of
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by

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Chapter 1

INTRODUCTION

1.1 Objectives and motivation

Teleaction Teleservice applications on ISDN are just emerging as commercial products. The main objective of this project is to study the standards, design and performance of Electronic Fund Transfer application on ISDN D channel. System design includes the description of system elements. Delay performance of ISDN D channel is investigated using SIMSCRIPT II.5 simulation language.

In comparison to the high speed, multi-media topics prevalent in today's communications business, teleaction teleservices are not glamorous. They operate at low data speeds and may not spin off new technologies. How ever they also have attractive features. They meet existing customer needs, they are relatively easy to deliver and new market opportunities exist for them. They can provide near term revenues for communications providers, near term market growth for service providers and wide variety of new, useful services for end users. The success of teleaction services could be a key to the future growth of the communications industry.

1.2 Need for new technology

In recent years the world's telecommunication networks have gone through a number of dramatic revolutionary changes. There are two basic factors contributing to this growth.

The first is the expanding nature of the user requirements in both commercial and residential environments. Today's communication is just not limited to voice but includes text, graphics, facsimile, audio and video. This is largely in step with the development of the digital computer and the technology of image processing.

Today's office and factory environments show that there is an increasing demand for the functions such as word processing, document transmission, data storage and retrieval, electronic mail, teleconferencing, accounting and payroll, production control, inventory control and computer-aided design and manufacturing. These facilities require sophisticated means for the transmission of information between computers, work stations, file servers, process controllers , and other intelligent machines.

There is a similar development in the modern home environment. Application of videotex services, use of personal computers for the electronic text communication and the evolution of television into high-resolution interactive entertainment medium is gradually increasing.

As the demand increases for the user applications there is a need for greater flexibility and simplicity in the use of available communication options and higher levels of integration and standardisation of the communication services, equipment, access procedure and tariffs.

The second factor contributing to this change is the increasing digitisation of telecommunications switching and transmission hardware. The development of inexpensive and highly reliable wideband communication media like optical fibre and the parallel development of software driven intelligent networks have allowed the implementation of new network-based services for the efficient and cost effective transmission, storage and processing of multimedia user information.

Integrated Services Digital Network (ISDN) is the logical culmination of these developments. It extends the benefits of the digital communications to the subscribers, makes the voice and non voice services of a network available via an integrated network access arrangement and has the potential of providing the subscribers with a high level of network services and facilities.

1.3 Principles and concept of ISDN

ISDN is not a new network, but it combines the available network services.

- The main feature of ISDN concept is the support of a wide range of voice and non voice applications in the same network. A key element of service integration for an ISDN is the provision of a range of services using a limited set of connection types and multipurpose user-network interface arrangements.
- ISDN supports a variety of applications including both switched and non switched connections. Switched connections include both circuit-switched and packet switched connections.

• An ISDN contains the intelligence for the purpose of providing the service features, maintenance and network management functions. This intelligence may not be sufficient for some new services and may have to be supplemented by additional intelligence within the network.

• The existing network switching systems and inband signalling techniques, still largely based on analog methods, must be replaced with digital stored program controlled exchanges and digital common channel signalling systems, through which user can access and control the network transmission facilities and services.

Figure 1.1 is an overview of ISDN concept.

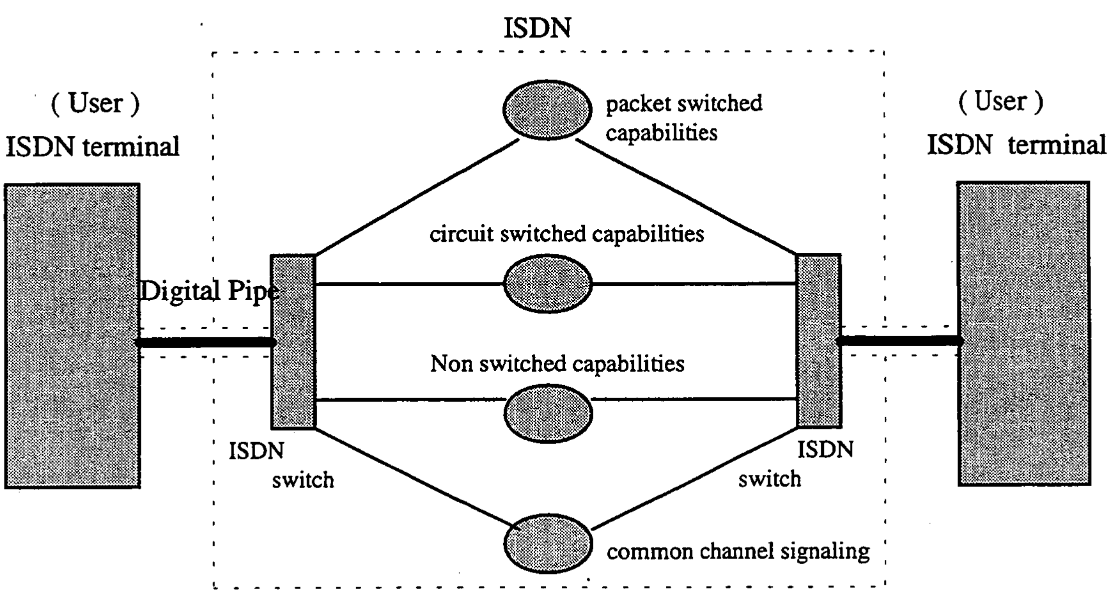


Figure 1.1 .

Today, the circuit switched telephone networks and the packet-switched data networks are the two separate networks operating independently. Neither of these networks has enough bandwidth for television. The TV network is again another separate network. In modern network design philosophy the node switches(computers) are programmed to provide basic transmission services. New user oriented services can be provided by intelligent peripherals and databases without having to redesign or upgrade the nodes. This architecture, however, requires efficient signalling to coordinate the network elements. This is provided by a Common Channel Signalling (CCS) network which is again another separate network. The Signalling System 7 (SS7) is internationally standardised protocol for the signalling messages on a CCS network. Thus we have the telephone set, the data set (with modem), the fax machine, the computer and the television, all accessing through a single delivery point to a number of separate networks which is the principle feature of ISDN.

1.4 Benefits of the ISDN

- A network configuration based entirely on digital transmission and switching offers the reduced cost, lower power consumption and easier maintenance.
- High level functionality of an ISDN and the integration of multiple connection types, services and user applications on a single network are expected to result in a higher utilisation of the network resources, with a corresponding increase in the network revenues.
- The ability to provide a variety of data communication services over a single digital subscriber line.
- From the end-user's perspective, one important benefit derives from the specification of standardised interfaces to the facilities of the ISDN. This feature, if implemented on a worldwide basis, would allow the design and manufacture of end user equipment on a large scale basis, leading to reduction in the cost of such equipment .
- The end to end digital connection offered by the ISDN eliminate the need for modems and is likely to provide a higher level of performance at a smaller cost than the currently available alternatives. In the long term the end users of an ISDN may also derive major benefits from the evolution of the network into an intelligent facility that can be modified to the user's precise needs, making possible such service features as bandwidth on demand.
- As far as the equipment manufacturer is concerned, the benefit of the ISDN lies in the potentially large market for standardised and service integrated user terminals and network termination devices.

1.5 ISDN-Application

Although the engineering features of an ISDN represent a significant advance in the capabilities and performances of telecommunications networks, the commercial success of ISDN will depend in large measure on the development of useful applications that are currently either unavailable, available in only limited geographic area or not cost effective.

Most important applications of the ISDN relate to the traditional voice communication services with certain enhanced service features. Included here are the transfer of standard digital voice at 64 kbit/s, compressed digital voice at various submultiples of 64 kbit/s, high -fidelity voice, and host of new and traditional call control procedures . Among these are calling party identification, multilocation ringing, call waiting, call forwarding and call charging indication, to mention just a few. Additional applications in this category are the provision of secure voice transmission, private voice mail services and services such as prerecorded announcements.

The second major category of application involves the transmission of programming material such as high fidelity audio, television, high-definition television and other Video material for entertainment and business use. Further examples are provided by video telephony and other multimedia applications involving simultaneous voice and Video.

The third category of applications is the requirements of a modern office. Most important of which are text and graphics message communications, including telex, teletex, videotex, electronic mail, facsimile and videoconference. Other uses such as PC-to-PC communications, local area network (LAN) interconnection, remote access to LAN, document storage and retrieval, database management.

The fourth potential source of applications is found in the intelligent building. Important functions here include smoke detection, temperature sensing and climate control, energy management, building access control and security monitoring.

Some of the specific applications include credit card authorisation in Automatic Teller Machine, utility meter reading and telemedicine.

1.6 ISDN Service

As ISDN applications step into new fields, services offered by the ISDN are standardised into three major categories namely Bearer Services, Teleservices and Supplementary Services. These services are defined by CCITT I.200 series.

Bearer services include 64-Kbps unrestricted service, useable for data transfer, speech information (PCM Coded digital) transfer, audio information (3.1 kHz). They also include high-speed digital transfer at rates of 384, 1536, and 1920 kbps that could be used for a variety of applications including video, private networking between PBXs, and links between other networks. The remaining services are packet-switched types of services similar to X.25 services. Here *unrestricted* means that the information is transferred without alteration.

Teleservices include telephony, telex, telefax, mixed mode(combined text and facsimile), videotex and telex.

Supplementary services are the services associated with a bearer service or teleservice. Primary objective of which defining these service is to provide higher level of convenience and user friendliness. They include Number Identification Supplementary Service, Call Offering Supplementary Services, Call Completion Supplementary Services, Call Completion Supplementary Services, Multiparty Supplementary services, Community of Interest Supplementary service and Teleaction Teleservices.

1.7 Teleaction Teleservice

Teleaction Teleservices is an umbrella term that covers a fragmented market of well-known, low data services. To name a few; electronic fund transfer, lottery transactions, security and surveillance system, energy management system, remote control of home appliances and utility meter reading. Teleaction services are defined by the International Telecommunication union (ITU), in Rec I.112, as follows: "Teleaction is a teleservice using short messages and providing a reliable low volume data communication and allied processing services". The teleaction services may be used for several applications, such as monitoring, indicating, controlling and verifying of remote events, operations and measurements, telealarms, telecommunication and telealerting. The services can be classified as follows.

- Transaction services(eg. electronic fund transfer, credit card authorisation at the point of sale).
- Alarm and surveillance service (eg. security and surveillance systems).
- Control and command services (eg., temperature monitoring systems, energy management systems, and remote control of home appliances).
- Meter reading services (eg. gas /electricity meter reading).
- Teleaction services that are associated with information services (eg. Access control to pay TV).

Table 1.1 shows the characteristics of teleaction teleservices.

1.8 Teleaction Teleservices on ISDN

There are several considerations and benefits to provide teleaction teleservices in ISDN.

• With the introduction of ISDNs, customers are expected to use their existing telephone line for their ISDN access. Teleaction services that are currently offered over the copper pair together with Plain Ordinary Telephone Service-POTS (Using data over voice techniques) will no longer be available unless offered by a different architecture. A need for a seamless and economic migration to ISDN therefore exists.

Characteristics of Teleaction Services
Low average throughput (0.1 to 50 b/s) and low data rates.
Interactive transactions.
Short time to delivery (typically less than a minute - end to end)
Traffic emanating from many terminals to one host.
Strong limitations on terminals and traffic cost.
Short header and short message length (typically less than 1 K bytes).
Stringent security and reliability requirements.

Table 1.1

• The ISDN customer access is expected to be less expensive in the future. Existing data over voice systems use analog filters that cannot easily be made price competitive.

• The low average throughput associated with teleaction teleservice implies that the ISDN D channel is a suitable candidate for the transfer of teleaction messages. The ISDN D channel (16 kbps) has the potential to be a "pipe" for several teleaction services.

• Operation, administration and maintenance for teleaction services can more easily be integrated with the systems used by the network operator for other voice and data services, there by reducing the costs of service and network management.

• With the user network interface being standardised, competition can reduce the teleaction terminal costs by increasing market volumes.
• ISDN services have the potential to create new powerful applications, by combining ISDN based teleaction services with the other types of ISDN teleservices. An example is video-telephony that may be used for telesurveilance purposes.

1.9 Credit card verification at the point of sale

Credit cards or smart cards provide an easy and efficient tool for electronic commerce. In today's competitive marketplace, providing customers with convenient payment options is almost as important as selling a quality product or service. Research shows that today's consumers are increasingly choosing checks, credit cards and debit cards as their preferred methods of payment. That is why it is so important to have the best equipment and support available for processing non-cash transactions. Credit card verification involves search of a remote database for verification. Most of the existing procedures make use of leased line facility. ISDN offers more economical communication for this purpose.

Automatic teller machine is one kind of transaction processing. Transaction processing services consummate a business transaction .They remotely check a database for available funds (possibly transferring the funds) and print a receipt. An automatic teller machine (ATM) transaction requires a credit card and dispenses both money and a written receipt , at the direction of the host processor. The scope of these transactions are no less than region wide and can be worldwide . For example , ATM transaction can cross national boundaries ,and the existing currency exchange rate can be automatically applied. These applications are enjoying significant market growth , and the growth is projected to increase for at least the next few years.

1.8 Summary

This thesis is a one semester project work for Master of Technology course in Information Systems. Fundamentals of ISDN technology, evolution of ISDN technology and CCITT recommendations on ISDN are discussed in the beginning of the thesis. Then a discussion of Teleaction Teleservices and Standards are covered. Study of access procedure and performance analysis of

ISDN D channel are investigated. A nonpreemptive queuing model is used for analysis. Average delay experienced by Signalling and Teletraffic messages for different utilisation are calculated. Both random service time and deterministic service time are considered in simulation. Simulation is investigated using SIMSCRIPT II.5 simulation language. Average delay and worst 5% delay experienced by teletraffic packets are calculated as a measure of performance. Details of credit card verification application and hardware design is also covered in the thesis. System design is carried using MITEL Semiconductor devices. Application notes for the relevant devices are included.

Chapter 2

ISDN DETAIL

2.1 Architecture

We are familiar with the concept of *Subscriber - Interface - Node - Link* in Telephone Network.

This is shown in the Figure 2.1 .

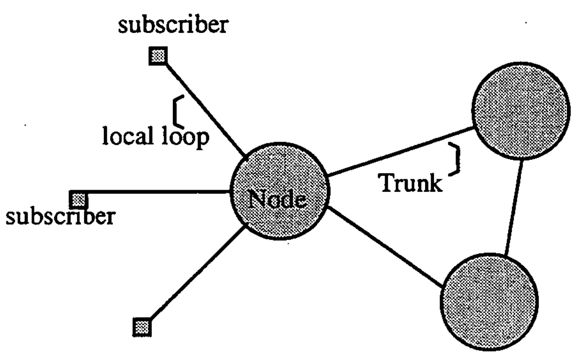


Figure 2.1

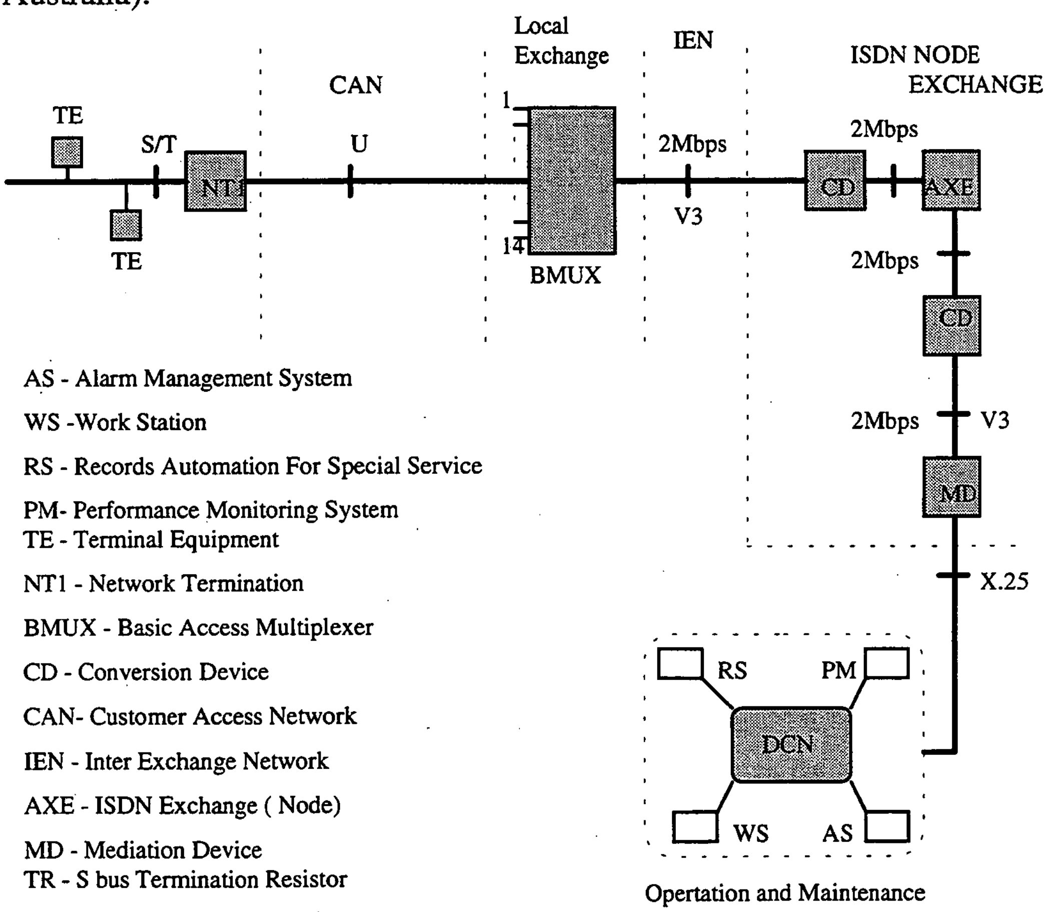
The *Subscriber* is the user or device attached to the network , which is telephone in this case. The *Interface* is the media between subscriber and switching station , which is familiar as local loop . A *Node* is the switching centre in the network. A *Link* is the connection between Nodes which also known as trunk.

The ISDN will support a completely new physical connector for users, a digital subscriber loop, and a variety of transmission services. A common physical interface provides a standardised means of attaching to the network . The same interface should be useable for telephone , computer terminal and videotex terminal. Protocols are required to define the exchange of control information between user device and the network . Provison is made for high speed interfaces to , for example , a digital PBX or LAN. The interface supports basic service consisting of three time -multiplexed channels , two at 64 kbps and one at 16 kbps. In addition , there is a primary service that provides multiple 64 -kbps channels.

The subscriber loop provides the physical signal path from subscriber to ISDN central office . This loop must support full duplex digital transmission for both basic and primary data rates. Initially much of the subscriber loop plant will be twisted pair. As the network evolves and grows , optical fibre will be increasingly used.

The ISDN central office connects the numerous subscriber loops to the digital network . This provides access to a variety of lower- layer (OSI 1-3) transmission functions, including circuit switched , packet switched and dedicated facilities. In addition common channel signalling , used to control the network and provide call management , will be accessible to the user.

Here a model of network configuration used in ISDN. Figure 2.2 shows Notion of a "Reference Configuration " in ISDN.(Reference. Telecom Australia).



AS - Alarm Management System
WS -Work Station
RS - Records Automation For Special Service
PM- Performance Monitoring System
TE - Terminal Equipment
NT1 - Network Termination
BMUX - Basic Access Multiplexer
CD - Conversion Device
CAN- Customer Access Network
IEN - Inter Exchange Network
AXE - ISDN Exchange (Node)
MD - Mediation Device
TR - S bus Termination Resistor
S/T , U ,V - ISDN Interfaces

Figure 2.2

2.2 ISDN Reference Configuration (CCITT)

Central to an ISDN is the interexchange network (IEN),. which consists of the physical and logical components of the backbone transmission network, including a number of network transit exchanges and the transmission trunks connecting these exchanges. There are two types of IEN , those providing circuit switched (CSIEN) connection and those based on the packet switching (PSIEN) . Superimposed on the IEN and interacting with it is the common channel signalling network (CCSN) , which combines some of the functions required for the control , management and maintenance of the ISDN.

The last major part of the ISDN - the subscriber access network (SAN) - consists of the part of the ISDN between the end user or subscriber and the IEN and CCSN . This can be divided into three components , namely the customer premises installation (CPI) , the digital section (DS) and the logical exchange termination. Following the block diagram representation of the above reference.

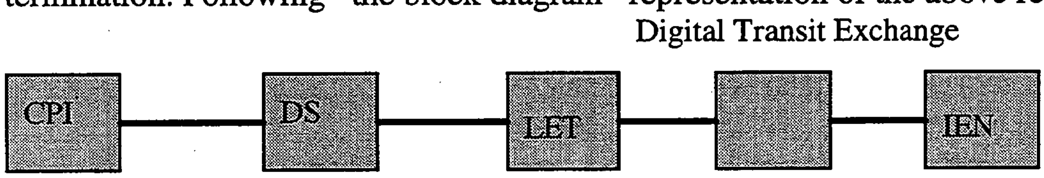


Figure 2.3

To specify the physical and logical properties of the SAN, IEN and CCSN , and to aid in the development of standard ISDN implementations , different parts of the network are divided into *Functional groups* and they are divided by conceptual points known as *Reference points*. Such a decomposition is known as Reference configuration.

The Subscriber Access Network Reference Configuration (User Reference Model)

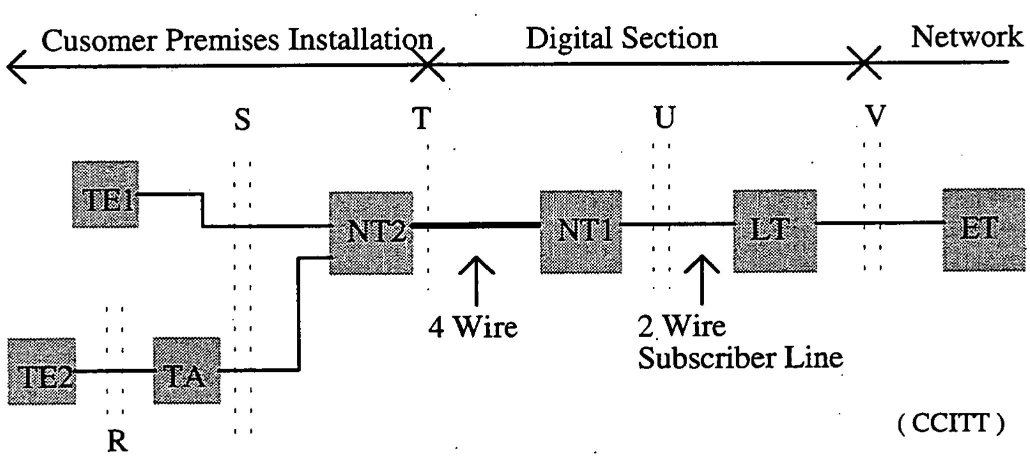


Figure 2.4

Functional Groups

1. *Terminal Equipment Type 1* (TE1) : This refers to devices that support the standard ISDN interface. Examples are digital telephone , integrated voice/ data terminals and digital facsimile.

2. *Terminal Equipment Type 2* (TE2): Encompasses existing non-ISDN equipment. Examples are terminals with non ISDN physical interface such as RS232 and host computers with an X.25 interface. Such equipment requires a *Terminal Adaptor* (TA) to plug into an ISDN interface .

3.*Network Termination 1* (NT1) : This includes functions that may be regarded as belonging to OSI layer 1 , that is the functions associated with physical and electrical termination of the ISDN on the user premises. NT1 supports multiple channels (2B +D) at the physical level . It supports multiple devices in a multi drop arrangement. For example a residential interface might include a telephone , personal computer and alarm system all attached to the single NT1 interface. For such configurations NT1 includes the contention resolution algorithm to control the access.

4. *Network Termination 2* (NT2) : This is an intelligent device that may include , depending upon the requirement , up through OSI layer 3 functionality . NT2 can perform switching and concentration functions . Examples of NT2 are a digital PBX , a terminal controller and a LAN.

5. *Exchange Termination* (ET) : This is the logical part of the central office to which the subscriber is attached and provides the functions necessary for the logical attachment of the SAN to the IEN . It performs signalling insertion and extraction , the conversion of information exchange codes., frame alignment and fault indication .

6. *Line Termination* (LT) : The physical aspects of terminating and timing the digital transmission system on the exchange premises are contained in the line termination. Specific functions include the feeding of power to the customer premise equipment and fault location through the loop back signals.

Reference points :

Reference point R corresponds to the point between a non ISDN terminal and Adaptor (TA). Reference point S corresponds to the point between a user equipment(TE1 or TA) and the network provider's equipment.(NT2). T reference point corresponds to the interface between NT1 and NT2 . The U reference point defines the interface between the NT1 and Line Termination. V reference point corresponds to the point between Line Termination and Exchange Termination..

2.3 ISDN Transmission Structure

The digital pipe between the central office and the ISDN subscriber is used to carry a number of communication channels. The capacity of the pipe and therefore number of channels carried , may vary from user to user. The transmission structure is constructed from the following types of channels :

- B channel : 64 kbps.
- D channel : 16 or 64 kbps.
- H channel 384 (H0) , 1536 (H11) or 1920(kbps).

The **B channel** is a user channel that can be used to carry digital data , PCM encoded digital voice , or a mixture of low rate traffic, including digital data and digitised voice encoded at a fraction of 64 kbps. Three kinds of connections that can be set over B channel are

- Circuit- switched : This is equivalent to switched digital service , available today. Call establishment does not take place on this channel.
- Packet Switched : The user is connected to a packet switching node and the data is exchanged with other users via X.25.
- Semipermanent : This is a connection to another user set up by prior arrangement and requiring call establishment protocol. This is equivalent to leased line.

Here the standard 64 kbps is derived from the fact that for speech signal with a bandwidth of 3.6 kHz and corresponding sampling rate of 8 kHz, we have for a sample size 8 bits/sample data rate equal to 64 kbps(Pulse Code Modulation).

The **D Channel** serves two main purposes . First it carries the common channel signalling information to control circuit- switched calls on associated B channels at the user interface. In addition to this the D channel may be used for packet switching or low speed (eg. 100bps) telemetry at times when no signalling information is waiting.

H channels are provided for user information at higher bit rates . The user may use such channel as a high speed trunk or subdivide the channel according to the user's own TDM (Time division multiplexed) scheme . Examples include fast facsimile , video, high speed data , high quality audio and multiplexed information streams at low data rates.

These channel types are grouped into transmission structures that are offered as a package to the user. The two available services are **Basic Rate Access(Narrow Band ISDN) and Primary rate Access(Broad Band ISDN).** Primary rate access is intended for users with greater capacity requirements , such as office with a digital PBX or a LAN . Primary Rate Access is available in two categories . 1.5442 Mbps and 2.048 Mbps. A 2.048 Mbps service provides 30 B channels at 64 kbps each and a D channel at 64 kbps. 1.544Mbps service provides 23B channels at 64 kbps and a D channel at 64 kbps.

2.4 Basic Rate Access (BRA)

Basic Rate interface consists of two full duplex 64kbps B channels and a full duplex 16 kbps D channel . The total bit rate is 144kbps . However , framing and synchronisation overhead bits make the link rate to 192kbps . This is intended to meet the needs of residential subscriber and very small offices. It allows the simultaneous use of voice and several data applications, such as packet-switched access, a link to a central alarm service , facsimile , telex , and so on. These services could be accessed through a single multifunction terminal or several separate terminals . In either case a single physical interface is provided . The B and D channels can be thought of as digital pipes and Basic Rate Access structure can be represented as shown in figure 2. Most existing two- wire local loops can support this interface . Hence , the transmission of 192 kbps on the existing subscriber loop becomes fundamental requirement.

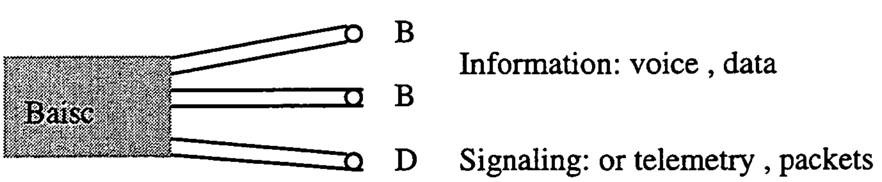


Figure 2.5

2.4 Digital Local Loops

Local loops (subscriber loops) are the link between subscriber and the network. Existing subscriber loops use Twisted Pair copper wire . Twisted pair subscriber loops were designed for analog transmission . Even though other mediums like optical fibre which support high data rate are available today, the cost of replacing twisted pair subscriber loops is very high. Hence different techniques are used for improvement of data rate on existing twisted pair. Following are the approaches for full duplex transmission on a subscriber line. First two are approaches are not used in current technology.

1. Full duplex FSK Transmission

Here the digital data is converted into analog signal using modem. Different frequency band is used for transmission in each direction . An example of this is use of frequency shift keying (FSK) to transmit digital data over an analog signal. A difficulty with this approach is only a half of the bandwidth is available for transmission in either direction. ISDN requires a minimum data rate 192 kbps which is very difficult to achieve with this technology ..

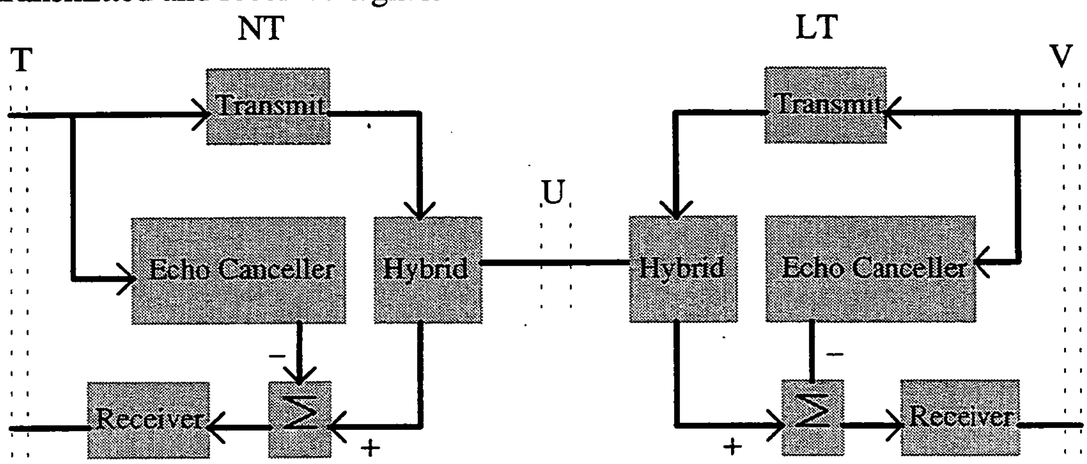
2. Time-compression Multiplexing (Ping-Pong method)

Instead of converting the digital data into analog data, digital data can be directly transmitted over the subscriber line. In this technique data are transmitted in one direction at a time , with transmission alternating between the two directions. Considering the fact that we have a finite transmission time ,finite propagation time and settling time the actual one way transmission rate must be greater than twice the full duplex data rate. In the case of Basic Rate Access (minimum 192 kbps) this rate is greater than 384 kbps.

3. Hybrid Echo Cancellation (current standard):

This allows the transmission in both the directions simultaneously, so that the data rate and transmission rate are equal. Signal separation at the transceiver is provided by a hybrid circuit. Echoes of the transmitted signal are removed by an echo canceller. Following is the block diagram for this system.

This method allows the data signals in the two directions to be transmitted within the same bandwidth. The impulse response of the undesired echo of the local transmit signal into the receiver is learned by an adaptive Echo canceller which also generates the exact replica of the echo and subtracts the replica of this to cancel the interference. The function of Hybrid circuit is to separate the transmitted and received signals.



HYBRID ECHO CANCELLATION SYSTEM   Adapted from IEEE Trans. Comm June 1985

Figure 2.6

2.5 ISDN Protocol Architecture For Basic Rate Interface

ISDN protocol architecture defines the standard protocols for interaction between ISDN users and the network. This protocol architecture differs from OSI (Open System Interconnection) model in the services like multiple related protocols, multimedia calls and multipoint connections.

In comparison with OSI and as a network , ISDN is essentially unconcerned with user layers 4-7 namely the Application , Presentation , Session and Transport layers. Network access is concerned only with layers 1-3 namely the Physical , Datalink and Network layers. This is shown in the figure 2.7

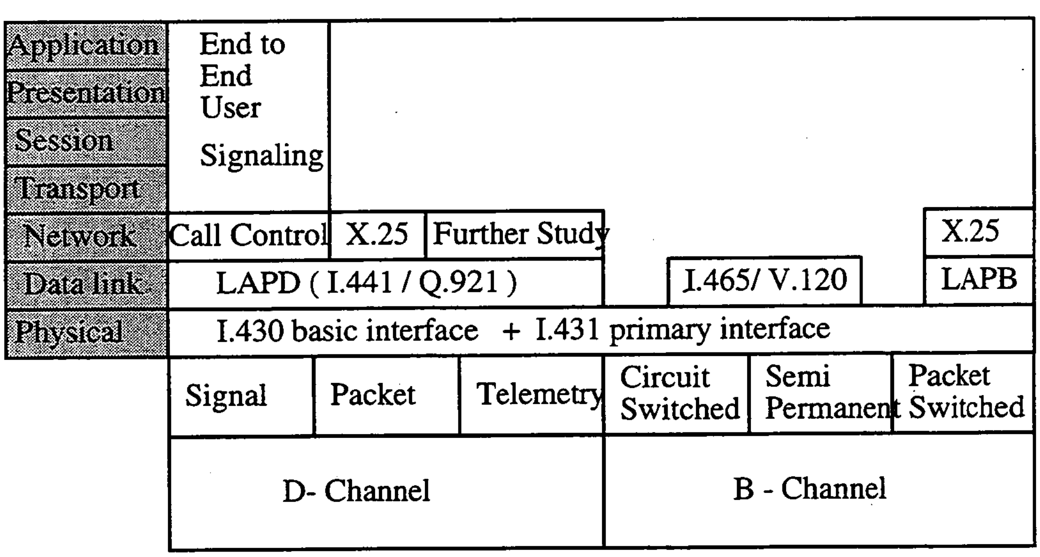


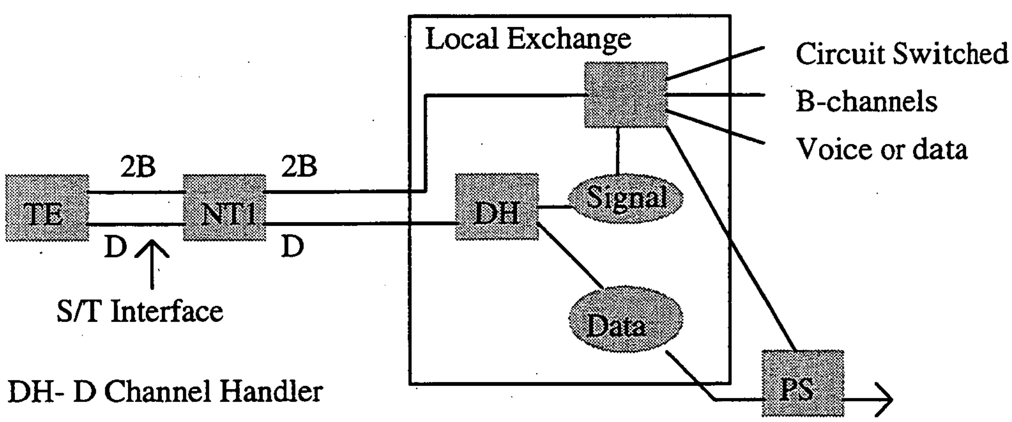
Figure 2.7

The D channel

For the D channel , a new data link layer standard , LAP - D (Link Access Protocol - D Channel) has been defined . The standard is based on High Level Data Link Control Protocol (HDLC) , modified to meet ISDN requirements. All transmission on the D channel is in the form of LAPD frames that are exchanged between the subscriber equipment and an ISDN switching element. Three applications are supported.

- S -type - for control signalling
- P- type - for low speed packet data
- T - type - for telemetry info - rates < X.1 rates ≈ 0.1 kbps.

D channel in ISDN performs the Out of Band Signalling functions. It can also be used for data transmission as a secondary option. Here the data rate is limited to 16kbps only. Figure2.7 shows the structure of D channel in ISDN.



DH- D Channel Handler

PS -Packet Switch

Figure 2.8

In this project, the functions and procedures related to local exchange are not considered. Area of interest is limited to " User Network Interface ". Before going through the protocol layers , two important topics of interest are " Terminal Adaption " and "Rate Aadaption ".

Many of the existing data communication equipment are not compatible with the interfaces, protocols and data rates of ISDN .The function of the Terminal Adaption is to accommodate the existing equipment for ISDN use. It maps a non ISDN terminal (like a personal computer , multiplexer , or modem) into an ISDN interface. Analog telephones and facsimile machines can also be accommodated. Following functions are performed by Terminal Adaptor.

- Rate adaption : A data stream of less than 64kbps is mapped into a 64kbps data stream.
- Signalling conversion : The signalling protocol of the device is mapped into the ISDN signalling protocol, I.451/Q.931. For many devices support interfaces such as X.21 or RS-232 , which provide an inband signalling protocol. These inband messages must be converted to D channel Q.931/I.451 messages.
- X.25 conversion : The functions of non ISDN x.25 devices are converted to operate on the B and /or D channel. This involves both rate adaption and signalling conversion.
- Physical interface conversion
- Digitisation : In the case of analog devices conversion is used.

2.6 ISDN Physical Layer

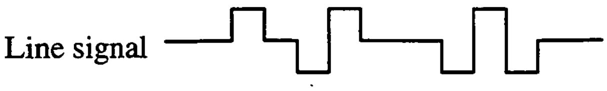
The Following functions are included as the functions of Physical layer(OSI -layer 1) for the basic user -network interface .(Recommendation I.430)

- Line coding
- Physical connector
- Framing and multiplexing.
- D - channel contention access resolution for multidrop configurations.

S/T Interface

Line coding : At the interface between the subscriber and the network terminating equipment (T or S reference point), digital data are exchanged using full duplex transmission on a 4 wire line. Hence full duplex transmission is achieved , without using Echo cancellation or TCM technique. The electrical specifications for the interface include a pseudoternary coding scheme. Binary one is represented by the absence of voltage ; binary zero is represented by a positive or negative pulse (750mV ± 10%) using alternate inversion. The data rate is 192kbps. Figure shows an example of Pseudoternary Coding.

Binary values 0 1 0 0 1 1 0 0 0 1 1



Basic Access Physical connector: This is defined by ISO standard 8887. This is an 8-pin connector.This terminates in matching plugs that provide 4,6,or 8 contacts.
Framing and Multiplexng: The basic access structure consists of two 64-kbps B channels and one 16-kbps D channel. These channels , which produce a load of 144kbps are multiplexed over 192 -kbps interface at the S or T reference point. Frame structure is as shown in the next Figure. 2.9

As with any synchronous time-division multiplex(TDM) scheme , basic access transmission is structured into repetitive, fixed- length frames. In this case , each frame is 48bits long ; at 192 kbps, frames must repeat at a rate of one frame every 250 µsec. Figure shows the frame structure. Two different frames are shown , one transmitted by NT (1 or 2) to TE and the other by TE to NT.

Frame from TE to NT.

Each frame of 48 bits includes 16 bits from the each of the B channels and 4 bits from the D channel.

Each frame begins with a framing bit (F) that is always transmitted as a positive pulse. (position 1). This is followed by a dc balancing bit set to a negative pulse to balance the voltage . The bit position and bit definitions are as follows.

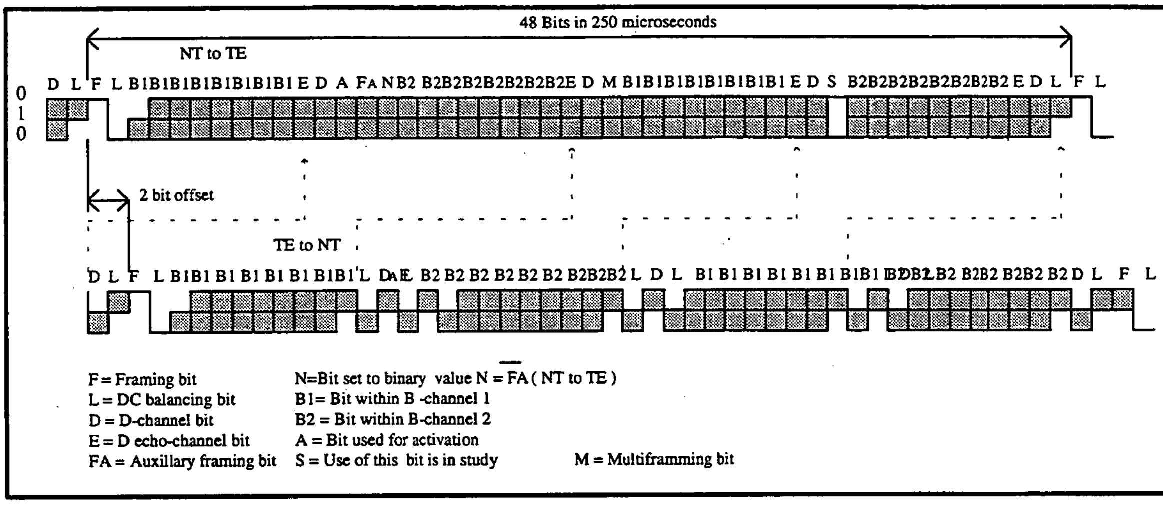

48 Bits in 250 microseconds
NT to TE
D L F L B1B1B1B1B1B1B1B1 E D A FA N B2 B2B2B2B2B2B2B2B2 E D M B1B1B1B1B1B1B1B1 E D S B2B2B2B2B2B2B2B2 E D L F L
0
1
0
2 bit offset
TE to NT
F = Framing bit
L = DC balancing bit
D = D-channel bit
E = D echo-channel bit
FA = Auxillary framing bit
N=Bit set to binary value N = $\overline{FA}$ (NT to TE)
B1= Bit within B -channel 1
B2 = Bit within B-channel 2
A = Bit used for activation
S = Use of this bit is in study
M = Multiframming bit

Figure 2.9

Bit position	Group
1 and 2	Framing bit (F) with balance bit (B)
3 -11	B1 channel (first octet) with balancing bit
12-13	D channel bit with balance bit
14 and 15	FA auxiliary framing bit with balance bit.
16 - 24	B2 channel (first octet) with balance bit.
25 and 26	D channel bit with balance bit
27 -35	B1 channel (second octet) with balance bit
36 and 37	D channel bit with balance bit.
38 - 46	B2 channel (second octet) with balance bit.
47 and 48	D channel bit with balance bit.

Frame transmitted by the NT contain an echo channel (E bits) used to retransmit the D bits received from the TEs. The D -echo channel is used for D channel access control. The last bit of the frame (L bit) is used for balancing each complete frame. The bits are grouped as follows.

Bit position	Group
1 and 2	Framing signal with balance bit
3 - 10	B1 channel (first octet)
11	E , D -echo channel bit
12	D channel bit
13	bit A used for activation
14	FA auxiliary framing bit
15	N bit coded as shown in the figure.
16- 23	B2 channel (first octet)
24	E , D -echo channel bit
25	D channel bit
26	M multiframing bit
27 -34	B1 channel (second octet)
35	E , D -echo channel bit

36	D channel bit
37	S spare bit
38-45	B2 channel (second octet)
46	E , D -echo channel bit
47	D channel bit
48	Frame balance bit.

Frame Alignment.

The timing of the transmissions by the terminal side at the frame, octet, and bit levels is extracted from the frames received from the network side, which inturn derives its timing from network clock. Thus, all transmission from the terminal side are synchronised to the reception from the network side . Frame Synchronisation is such that each frame transmitted from a TE toward the NT is later than the frame in the opposite direction by two bit times. This delay allows the terminal side to properly synchronise the received frame and provides the flexibility to align the transmissions from multiple TE's on a passive bus to a common bit clock. To assure that the transmitter (NT or TE) and receiver (TE or NT) do not get out of alignment , the frame structure includes deliberate violations of the pseudoternary code . The receiver looks for these violations to assure the frame alignment is being maintained. Two violations are included :

- The first F bit ; This is always a positive zero.The frame is structured so that the last zero bit of the frame is positive.
- The first zero bit after the first L bit : Both of these bits are negative polarity. The second violation occurs at the FA bit at the latest.

Multiframe Structure

A recently added feature of the basic interface specification is the provision for an additional channel for traffic in the TE-to-NT direction , called the Q channel . At present , the use of the Q channel for is for further study . To implement the Q channel , a multiframe structure is established by setting the M bit (NT - to -TE direction) to binary 1 on every twentieth frame. In the TE - to NT direction , the FA bit in every fifth frame is a Q bit. Thus in each 20-frame multiframe there are 4 Q bits .

Multidrop Configuration And Contention Resolution

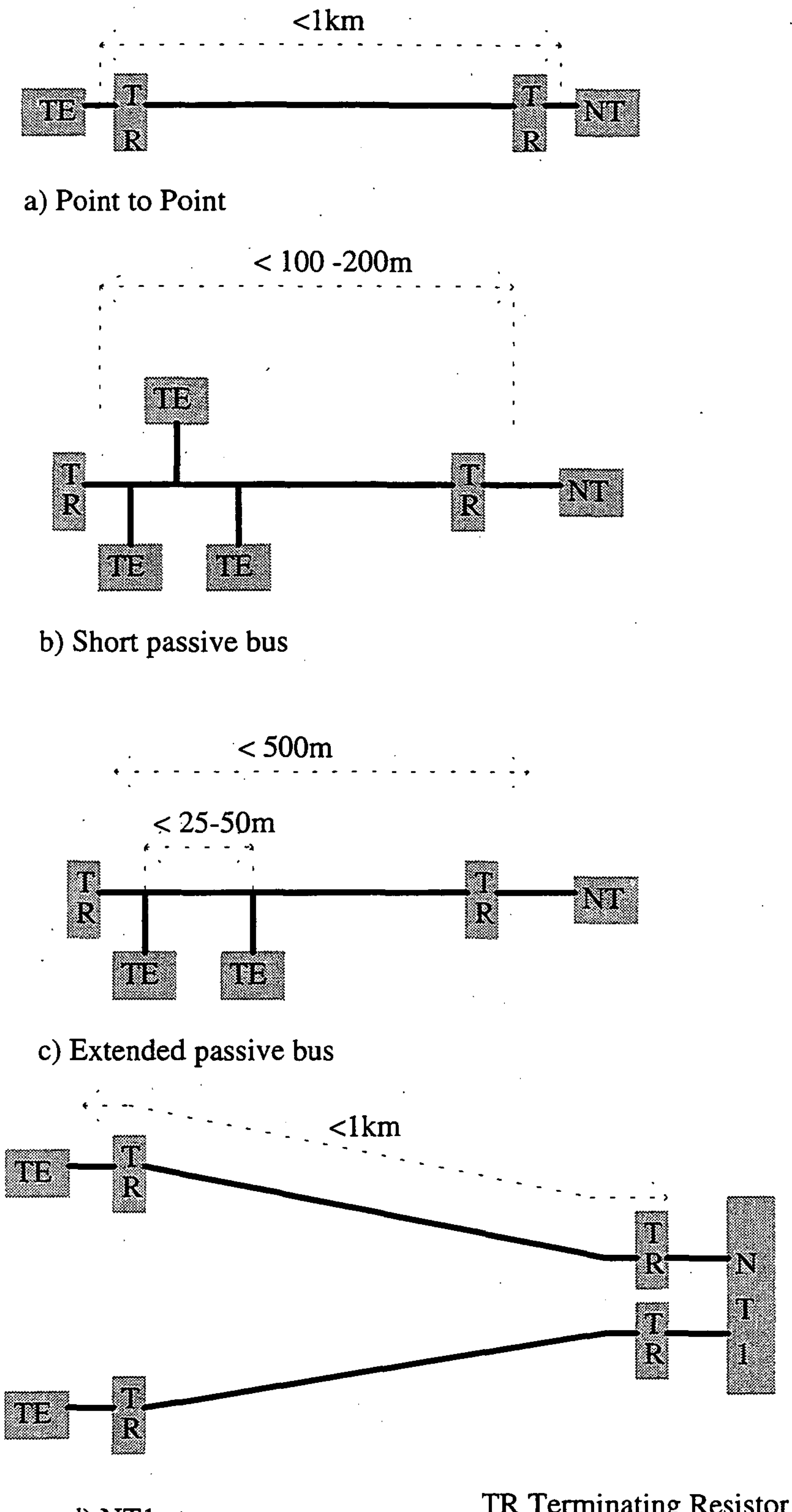
Basic rate interface passive bus configuration is as shown in the figure. this allows more than one TE device. The simplest is a point to point configuration with only one TE. In this configuration the maximum distance between the NT equipment and the TE is the order of 1km. The second configuration is referred to as multidrop configuration which imposes limitations on the distances involved. For basic rate interface , CCITT specifies a maximum distance between NT and TE is between 100 and 200 meters , with a maximum of 8 TE's connected at random points connected along the interface points.

With the multidrop configurations shown in Figure 2.10 , there is a contention problem. In the case of the two B channels , no additional functionality is needed, since each channel is dedicated to a particular TE at any given time. How ever the D channel is shared by all TEs for control signalling and D channel packet transmission. For incoming data LAPD addressing scheme is sufficient to sort out the proper destination . For outgoing data , some sort of contention resolution is protocol is needed to assure that only one device at a time attempts to transmit.

The D channel contention algorithm has the following elements:

1. When a subscriber device has no LAPD frames to transmit , it transmits a series of binary ones on the D channel . Using the pseudoternary encoding scheme, this corresponds to the absence of signal.
2. The NT , on the receipt of a D channel bit , reflects back the binary value as a D channel echo bit (E bit).
3. When the terminal is ready to transmit an LAPD frame ,it listens to the stream of incoming D channel echo bits. If a string of 1 bits of length equal to threshold value Xi is detected , then it may transmit. Otherwise , the terminal must assume that some other terminal is transmitting and wait.
4. It may happen that several terminals are monitoring the echo stream and begin to transmit at the same time , causing a collision . To overcome this condition , a transmitting TE monitors the echo bits and compares them to its transmitted bits . If a discrepancy is detected , the terminal ceases to transmit and returns to a listen state.
5. The counter need not be incremented after the count 11 has been reached.

Priority Mechanism.



a) Point to Point

b) Short passive bus

c) Extended passive bus

d) NT1 star

Figure 2.10

To differentiate between the various uses , the control of the D channel is based on a dual priority scheme. Layer 2 frames are transmitted in such a way that signalling information are given priority (class 1) over all other types of information (priority class 2). Further to ensure that within each Priority class all competing TE's are given a fair access to the D channel , once a TE has successfully completed the transmission of a frame , it is given a lower level of priority within that class. The TE is given back its normal level within a priority class when all TE's have had an opportunity to transmit information at the normal level within that priority class.

The priority mechanism is based on the requirement that a TE may start layer 2 frame transmission only when C(count of D echo channel ones) is equal to , or exceeds , the value X1 for priority class 1 or equal or exceeds , the value X2 for priority class 2 . The value of X1 shall be 8 for the normal level and 9 for the lower level of priority . The value of X2 shall be 10 for the normal level and 11 for the lower level of priority.

In a priority class the value of the normal level of priority is changed into the value of the lower level of priority when a TE has successfully transmitted a layer 2 of that priority class .

If the terminal wants to transmit control information and is currently in normal priority , it may initiate the transmission as soon as count C reaches the value 8 , where as the lower priority it must accumulate a count C =9 . For all other types of information flows such as user data , the count must reach 10 and 11 respectively.

Priority class of a particular layer 2 frame may be a characteristic of the TE which is preset at the manufacture or at the installation or it may be passed down from layer 2 as a parameter of the PH- data request primitive.

2.7 U Interface

The line coding used at the U interface is known as two binary one quaternary (2B1Q) coding. This code provides for more efficient use of bandwidth by having each signalling element represent two bits instead of one. Four different voltage levels are used. Since each signal element can take four possible values , two bits of information are conveyed . Table 2.1 shows the definition of 2B1Q.

First Bit (polarity)	Second Bit (magnitude)	Quaternary Symbol	Voltage Level (Volts)
1	0	+3	2.5
1	1	+1	0.833
0	1	-1	-0.833
0	0	-3	-2.5

Table 2.1

The bit rate (data rate) and the baud rate (signal level) in this case are related by the following relation. $D = R/b = R / \log_2 L$

where

D = modulating rate , bauds.

R = data rate ,bits.

L = number of different signal elements.

b = number of bits per signal element.

Framing and Multiplexing:

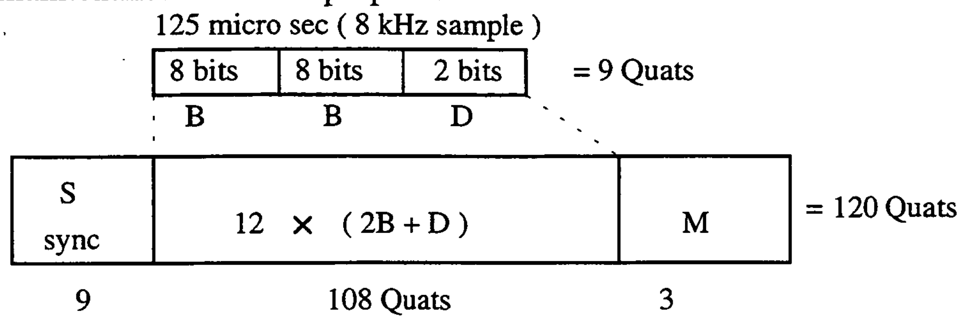
The basic access structure consists of two 64 -kbps channels and one 16-kbps D channel . These channels , which produce a load of 144 kbps , are multiplexed over a 160 kbps interface at the U reference point. The remaining capacity is used for various framing and synchronisation purposes.

As with any synchronous time division multiplexed (TDM) scheme , basic access transmission is structured into repetitive, fixed length frames . In this case , each frame is 240bits long ; at the rate of 160kbps, frames must repeat at a rate of one frame every 1.5 msec. Figure 2.11 shows the frame structure.

•Synchronisation word :The first nine symbols (18) bits of the frame form a synchronisation word , with the quaternary symbols in the sequence (+3 +3-3 -3-3+3-3+3-3), except as noted subsequently . This word allows the receiver to synchronise on the beginning of each frame.

•User data : The next twelve groups of 18 bits of each carry B and D channel data.

•M channel : The last 6 bits of the frame form a 4-kbps M channel for maintenance and other purposes.



Overall 240 bits in 1.5 msec or 160 kbps (80 kilo baud)

Figure 2.11

The interleaving of B and D bits is different at the U reference points (8B1 , 8 B2, 2D) than at the S and T reference points (8B1, D, 8B2 , D). Since the channel data rates are the same at all three reference points , this presents only a minor buffering problem. The NT1 is responsible for the conversion between the two different frame formats.

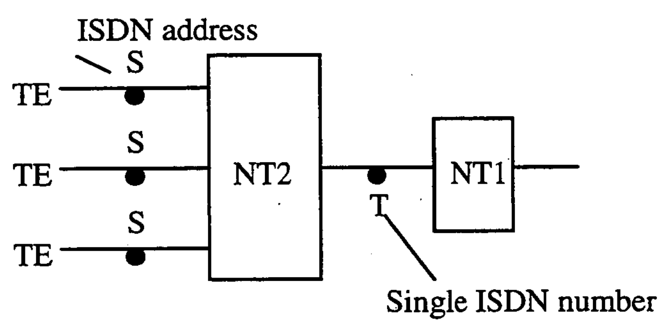
The basic frame structure is organised into superframe concisting of 8 frames each . The first frame of the superframe is identifies by inverting the polarity of the synchronisation word in that frame , with pattern (-3 -3 +3+3+3-3+3-3+3).

2.8 ISDN Address Structure

CCITT makes a distinction between a number and an address. An ISDN number is one that relates to the ISDN network and ISDN numbering plan. It contains sufficient information for the network to route a call. Typically ISDN number corresponds to the subscriber attachment point to the ISDN ie to the T reference point . An ISDN address comprises the ISDN number and any optional additional addressing information. This additional information is not needed by the ISDN to route the call but is needed at the subscriber site to distribute the call to appropriate party. Typically an ISDN address corresponds to the S reference point . The situation is shown in figure 2.12a.

Figure 2.12b shows the ISDN address . An address in this format would appear in call set up messages communicated in common- channel signalling protocols such as Signalling System Number 7. The elements of the address are

- *Country code:* Specifies the destination country of the call. It is composed of variable number of decimal digits (1 to 3) and is defined in Recommendation E.163 (existing telephony numbering plan).
- *National destination code*: is of variable length and a portion of the national ISDN number . If subscribers within a country are served by more than one ISDN and /or public switched telephone network(PSTN), it can be used to select a destination network within the specified country.
- *ISDN subscriber number*: is also of variable length and constitutes the remainder of the national ISDN number. Typically , the subscriber number is the number to be dialled to reach a subscriber in the same local network.
- *ISDN subaddress*: provides additional addressing information and is a maximum 40 digits in length



a)

Country Code	National destination Code	ISDN Subscriber number	ISDN subaddress (max 40 digits)

National ISDN number

International ISDN number(max 15 digits)

b) Structure of ISDN Address.(maximum 55 digits)

Figure 2.12

2.9 ISDN Datalink Layer

All traffic over the D channel employs a link layer protocol known as LAP-D defined in I.441/Q.921. The purpose of LAPD is to convey user information between layer 3 entities across ISDN using the D channel. The LAP-D services will support

- Multiple terminals at the user - network installation
- Multiple layer 3 entities (eg . X.25 level 3 , I.451/Q.931).

LAP-D Protocol:

The LAP-D protocol is modelled after the LAPB protocol used in X.25 and on HDLC(High Level Data Link Control protocol). Both user information and protocol-control information are transmitted in frames. LAP-D is a balanced mode operation: that is NT and TE entities have equal status. The purpose of LAP-D is to convey user information between layer 3 entities across ISDN using the D channel. LAP-D standard provides two forms of services to LAP-D users.

1. The unacknowledged information transfer service.
2. Acknowledged information transfer service.

The *unacknowledged information* transfer service simply provides for the transfer of frames containing user data with no acknowledgment. This service is used for fast data transfer and is useful for management procedures.

The *acknowledged information* transfer service is similar to service offered by LAPB and HDLC. In this type of connection there are three phases.

1. Connection Establishment phase: The two users agree to exchange acknowledged data.
2. Data transfer phase: LAP-D guarantees that all frames will be delivered in the order that they were transmitted.
3. Connection termination phase: One of the two users requests termination of the logical connection.

These two types of services may coexist on a single D channel.

Frame Structure:

All user information and protocol messages are transmitted in the form of frames.

FLAG	ADDRESS	CONTROL	INFORMATION	FCS	FLAG
8	16	8 or 16	VARIABLE	16	8

bits

Figure 2.13

Flag fields :

These delimit the frame at both the ends with the unique pattern '01111110'.A single flag can be used as the closing flag for one frame and opening flag for the next frame. The flag field are used for synchronisation. As there is no restriction in the content of the fields, there is a chance of '01111110' pattern appearing in the frame, thus destroying synchronisation. To avoid this ,there is a procedure known as **'Bit Stuffing'.** Between the transmission of starting and ending flags, the transmitter always insert an extra '0' bit after each occurrence of five 1's in the frame. After detecting a starting flag the receiver monitors the bit stream. When a pattern of five 1's appears, the sixth bit is examined. If this bit is '0', it is deleted. If the sixth bit is a '1' and the seventh bit is a '0', the combination is accepted as a flag. If the sixth and seventh bits are '1', then the sender is indicating an abort condition.

Address Field .

It has the following format .

Bits 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

0	C/R	SAPI	1	TEI

C/R command /response

SAPI service access point identifier

TEI terminal endpoint identifier

Figure 2.14

LAP-D has to deal with two levels of multiplexing.

1. One is at TE site, there may be multiple terminals sharing the same physical interface.

2. Second, within each TE, there may be multiple types of traffic like packet switched data and control signalling.

To accomplish the above two jobs, LAP-D employs a two part address, consisting of terminal endpoint identifier(TEI) and a service access point identifier (SAPI.).

Each terminal equipment is given a TEI. It is also possible for a single terminal to be assigned more than one TEI. TEI assignment occurs either automatically when the equipment first connects to the interface or manually by the user. The advantage of the automatic procedure is that it allows the user to change, add or delete equipment at will without prior notification to the network administration.

Table 2.2 shows the TEI and SAPI assignments.

SAPI Assignments.

SAPI Value	Related Protocol or Management entity
0	Call control procedures
1	Reserved for packet mode communication using I.451 call control procedure
16	Packet communication confirming to X.25 level 3
32-62	Frame relay communication
63	Layer 2 management procedures
All others	Reserved for future standardisation

Table 2.2

TEI Assignments

TEI Value	User Type
0-63	Nonautomatic TEI assignment user equipment
64-126	Automatic TEI assignment user equipment
127	Used during automatic TEI assignment

Control Field Format

Following are the control field formats.

1 2.. 8 9 10.. 16

0	N(S)	P/F	N(R)	Information transfer

1	0	SS	0 0 0 0	P/F	N(R)	supervisory

1	1	M M	P/F	M M M	Unnumbered

Information transfer frames (I frames) : are used for information transfer between layer 3 entities. The functions of N(S), N(R) and P independent; that is, each I frame has an N(S) sequence number, an N(R) sequence number which may or may not acknowledge additional I frames received by the data link layer entity.

Supervisory frames: The supervisory frames are used to perform data link supervisory control functions such as ; acknowledge Information frames, and request a temporary suspension of transmission of I frames. The functions of N(R) and P/F are independent; that is, each supervisory frame has an N(R) sequence number which may or may not acknowledge additional I frames received by the data link layer entity, and a P/F bit that may be set to "0" or "1".

Unnumbered frames (U-frames) : are used to provide additional data link control functions and unnumbered information transfers. These frames do not have sequence numbers. It does include a P/F bit that may be set to "0" or "1".

The first one or two bits of the control field identify the frame type. All the control field formats contain the poll/final bit. In command frame, it is referred to as 'P' bit and set to 1, to solicit (poll) a response frame from the peer

LAP-D entity. In response frames, it is referred to as F bit and is set to 1 to indicate the response frame transmitted as a result of a soliciting command.

Information field : The information field is present only in I-frames and some unnumbered frames. The field can contain any sequence of bits but must consist of integral number of octets. I.441/Q.921 specifies a maximum length of 260 octets.

Frame check sequence field: The FCS is an error detecting code calculated from the remaining bits of the frame ,exclusive of all flags. The code is defined by the CRC-CCITT. .

2.10 Frame-Mode Bearer Service And Protocol

The traditional approach to packet switching is X.25 protocol. X.25 has following key features.

- Call control packets , used for setting up and clearing virtual circuits , are carried on the same channel and same virtual circuit as data packets . In effect inband signalling is used .
- Multiplexing of virtual circuits takes place at layer 3.
- Both layer 2 and layer 3 include flow-control and error control mechanisms .

This approach results in considerable overhead . At each hop through the network , the data link control protocol involves the exchange of a data frame and an acknowledgment frame . Furthermore , at each intermediate node , state tables must be maintained for each circuit to deal with the call management and flow-control / error-control aspects of X.25 protocol.

Frame relaying is designed to eliminate as much as possible of the overhead of X.25 . The key difference of frame relaying from a conventional X.25 packet -switching service are

- Call -control signalling is carried on a separate logical connection from user data except when the D channel itself carries data. Thus , intermediate nodes need not maintain state tables or process messages relating to call on an individual per -connection basis.
- Multiplexing and switching of logical connection takes place layer 2 instead of layer 3 , eliminating one entire layer of processing.
- There is no hop by hop flow control and error control . Error control are the responsibility of a higher layer , if they are employed at all.

Figure 2.15 depicts the protocol architecture for frame relay . As in other areas of ISDN , we need to consider separate planes of operation : a control (C) plane, which involves establishment and termination of logical connection , and a user plane which is responsible for the transfer of user data between subscribers. Thus , C- plane protocols are between a subscriber and the network , while U plane protocols provide the end to end functionality.

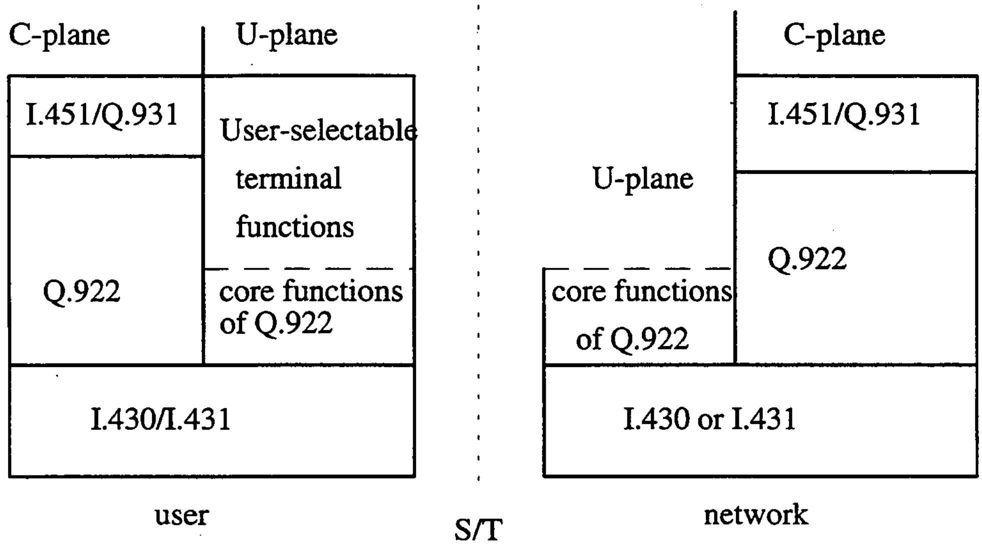


Figure 2.15

Only the core functions of Q.922 are used for frame relay:

- Frame delimiting , alignment , and transparency.
- Frame multiplexing / demultiplexing using the address field.
- Inspection of frame to ensure that it consists of an integer number of octets prior to zero bit insertion or following zero bit extraction.
- Inspection of the frame to ensure that it is neither too long nor too short.
- Detection of transmission errors
- Congestion control functions.

2.10 ISDN Network Layer- Layer 3

Layer 3 utilises functions and services provided by the data link layer. These services are summarised below:

- establishment of data link connections
- error-protected transmission of data
- notification of unrecoverable data link errors

- release of data link connections
- notification of data link layer failures
- recovery from certain error conditions
- indication of data link layer status

Structure of layer 3

Categories of functions

There are two categories of functions performed at layer 3 in the establishment of network functions. The first category contains those functions which directly control the connection establishment.

The second category contains those functions relating to the transport of messages additional to the functions provided by the data link layer. An example of the additional layer 3 functions is the provision of re-routing of signalling messages on an alternate D-channel (where provided) in the event of D-channel failure. Other possible functions in this category may include multiplexing and message segmenting and blocking.

Basic functions to be performed at the network layer for call control.

The functions support procedures for both basic call control and call control in conjunction with network-provided supplementary facilities. Furthermore, services involving the use of connections of different types, according to the user's specification, may be effected through "multi-media" call control procedures.

Functions performed by layer 3 include the following :

- processing of primitives for communicating with the data link layer;
- generation and interpretation of layer 3 messages for peer level communication;
- administration of timers and logical entities used in the call control procedures;
- administration of access resources including B-channels and packet-layer logical channels
- checking to ensure that services provided are consistent with user requirements
- routing and relaying
- network connections
- conveying user-to-network and user-to-user information;
- network connection multiplexing
- segmenting and blocking;

- error detection;
- error recovery;
- flow control;
- reset.

2.11 ISDN : Compatibility with existing networks

Two families of data services can be offered in an ISDN in relation to the transfer mode; circuit mode data services and packet mode data services. The circuit mode data services are typically offered in a N-ISDN and are accessed via the B channel at 64 kbits/sec.

Interworking with existing systems :

It is clear that there is never likely to be a single, monolithic, worldwide ISDN. In the near future, there will be a variety of non-ISDN public networks operating, with the need for subscribers on these networks to connect to subscribers on ISDN networks. Even in the case of different national ISDNs, differences in services or the attributes of services may persist indefinitely.

To provide compatibility between ISDN and existing network components and terminals, a set of interworking functions must be implemented. The functions are as follows.

1. Provide interworking of numbering plans.
2. Match physical layer characteristics at the point of interconnection between the networks.

Some additional reference points are defined by ITU for standardising the interworking capability.

K: Interface with an existing telephone network or other non-ISDN networks requiring interworking functions. The functions are performed by ISDN>

L: As with K. but it is the responsibility of the other network to perform the interworking functions.

M :A specialised network, such as teletex or MHS. The functions are performed in specialised network.

N: Interface between two ISDNs.
P: Interface between an ISDN and a specialised resource that is provided by the ISDN provider.

As defined by CCITT (ITU), there are five other types of networks that support telecommunication services, that are supported by ISDN.
Interworking refers to the capability for an ISDN subscriber to establish a connection to a subscriber on a non-ISDN network.

1. ISDN - ISDN Interworking.
2. ISDN - PSTN Interworking.
3. ISDN - CSPDN Interworking.
4. ISDN - PSPDN Interworking.

Chapter 3

TELEACTION TELESERVICES

The term teleaction means "acting at a distance". The actions include reading or writing some information to a remote location or possibly both. Instead of sending a person to set or read some information on a device , it is done remotely via a communication network.This form of data collection is extremely useful when coupled with a computer system that could use the data to initiate action .(eg., dispatch a repair person , generate bill, etc.)

There are three important identities in teleaction services, namely "end user", "carrier " and " service provider". The end user is the ultimate user of the service, the carrier is the company that delivers the data channel on which the service rides and the service provider is the company that processes the information that sent over the data link. Consider the lottery service as an example: the end user is the local business, the lottery service provider generates the ticket information and the local telephone company carries the information.

3.1 Service Overview

Most of the teleaction services are intended for small business and residential customer . Table 3.1 shows how we can classify the teleaction teleservices .

Transaction Processing- Transaction processing services consummate a business transaction .They remotely check a database for available funds (possibly transferring the funds) and print a receipt.

For point-of -sale(POS) application , a credit card or debit card transaction initiates remote processing. The card is read and a purchase authorisation is reported.The transaction is complete after the customer receives a printed receipt.

For each transaction application shown in the table ,the need exists to provide rapid , accurate processing of the transactions. The transaction is initiated by either a special card or login procedure to dedicated processing computers. Usually these computers are centrally located in a region or a country. The privacy and security of the information are becoming increasingly important. Also some transactions take no more than a few seconds .

General categories	Applications
Transaction Processing	Point of sale (credit cards) Lottery Automatic teller machines Medical insurance claims
Alarm and Serveillance	Burglary, fire, smoke Medical, disabbled persons Environment Avalanches
Business Automation	Information access Data processing
Utility resources management	Automatic meter reading Time of day rate information Load shedding
Control and command	Appliances, thermostat, light etc

Table 3.1

Alarm and surveillance : - Alarm and surveillance is a service that monitors factors affecting individual or public safety. Security alarms today typically monitor burglary ,fire and smoke surveillance equipment .Specific detectors within a premises check for alarm conditions and report an activation condition to an alarm panel.The panel typically initiates an audible alarm , and reports an alarm condition to the remote monitoring station .

Utility Resources Management - Gas , water, and electric utility companies are increasingly interested in using communication technology to better manage the use and distribution of their resources. The utilities want to measure the consumption through Automatic Meter Reading . There is also growing interests in providing the end user with time -of -the day rates and using load shedding .

3.2 Architectural Framework for the provision of Teleaction Services

Common properties of Teleaction Services : Observing many of the teleaction Services , one can identify common properties

• Large number of low cost terminals (eg., gas meters , fire detectors) coupled with a requirement for low communication cost

• Short messages from the terminal to a given host - typically not more than a few hundred bytes . Examples are financial transactions , alarms and meter reading reports.

• Traffic originated from many terminals to few hosts .

• Low average throughput (eg 0.1 to 50 b/s) from a terminal to a given host . However , peak traffic may be high as many terminals send messages at the same time.

• Low data rates (typically up to 19.2 kb/s).

• Stringent requirements as to the response time to individual transactions and the reliability.

3.3 Reference Physical Architecture

Due to the similarity in their basic properties , a general reference physical architecture for the provision of teleaction services can be developed .A general reference physical architecture for the provision of teleaction services is illustrated in the Figure 3.1 .

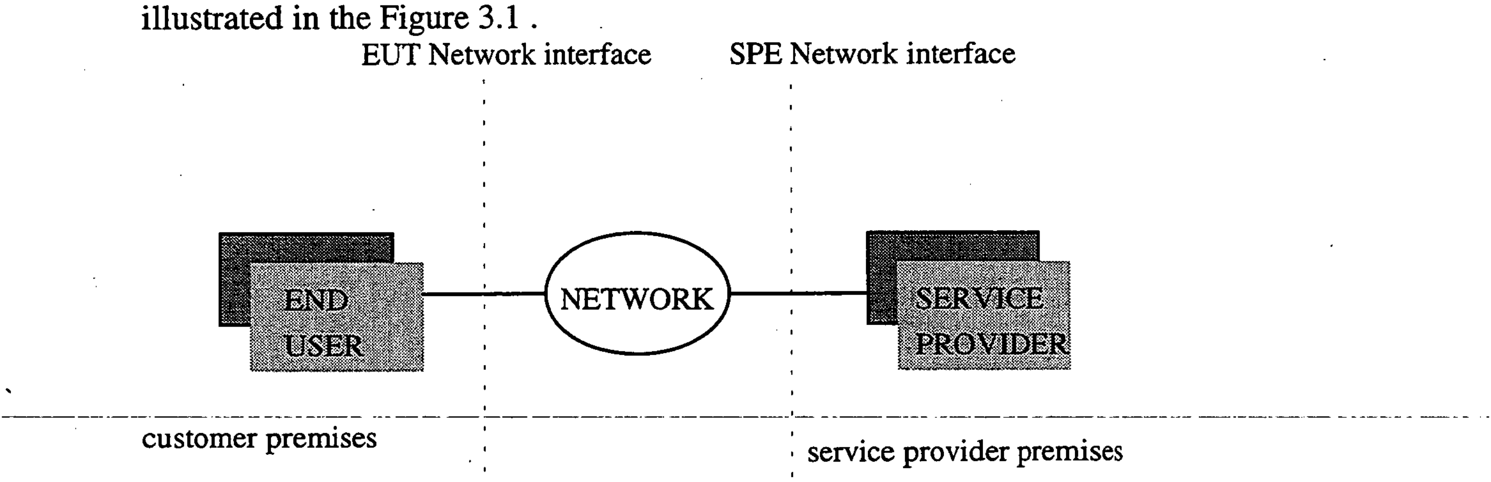


Figure 3.1

The reference physical architecture has three parts :

• End User Terminal (EUT) which resides in the customer premises . Examples are : point of sale terminals , electricity meters.

• The network is the medium that is used to transfer the information from end user Examples of network implementations are : dedicated message switches , Publi c Switched Packet Data Netowrks (PSPDNs) , ISDNs .
• Service Providers Equipment (SPE) which resides in the service providers premises : Examples of service provider equipment are host of financial institutions and alarm display terminals .

Generic Teleaction Message Delivery Service
An analysis of a variety of teleaction services reveals that there is a common need for an application independent secure teleaction message delivery service from the end user terminal to the service provider equipment and vice versa. Following functions are considered to be applicable for such a delivery service.
• Notification to the service provider of any loss , modification , or deletion of message s.
• Broadcast - message broadcasting from a service provider to a number of destinations
• Message delivery according to the predefined priority levels.
• Alternating routing in case of failure of the network equipment .
• Traffic logging for audit and statistical purposes .
• Message grouping
• Protection against active attacks such as message modification , message deletion or message replacement.
• Secure permanent monitoring of the terminal in order to detect any deliberate disconnection by an intruder .
• Notification to the service provider , if a terminal becomes inactive .

3.4 Provison Of Teleaction Service In An ISDN Environment

There are several considerations and benefits to provide teleaction services in ISDN
• With the introduction of ISDNs , customers are expected to use their existing telephone line for their ISDN access. Teleaction services that are currently offered over the copper pair together with POTS (Data Over Voice technique)

will no longer be available unless offered by a different architecture. A need for seamless and economic migration to ISDN therefore exists.

- ISDN customer access is expected to be less expensive in the future.
- The low average throughput associated with teleaction services implies that the ISDN D channel is a suitable candidate for the transfer of the teleaction messages. The ISDN D channel (BRI - 16Kbps) has the potential to be a "pipe" for several teleaction services at the same time as it allows multiplexing of several bit streams. The packet -type nature of D channel communication with a data rate up to 9600 b/s in good accordance with the characteristic requirements of most of the teleaction services.
- Operation , administration and maintenance for teleaction services can more easily be integrated with the system used by the network operation for other services, there by reducing the costs of services, and network management.
- ISDN services have the potential to create a new powerful applications, by combining ISDN based teleaction services. An example of this is video-telephony that may be used for Teleserveilance purposes.

3.5 Standardisation Framework For ISDN Teleaction Services

ISDN Teleaction teleservices are yet to be standardised. International Telecommunication Union (ITU) is working in this direction. Following is the reference model for the support of teleaction services by an ISDN.

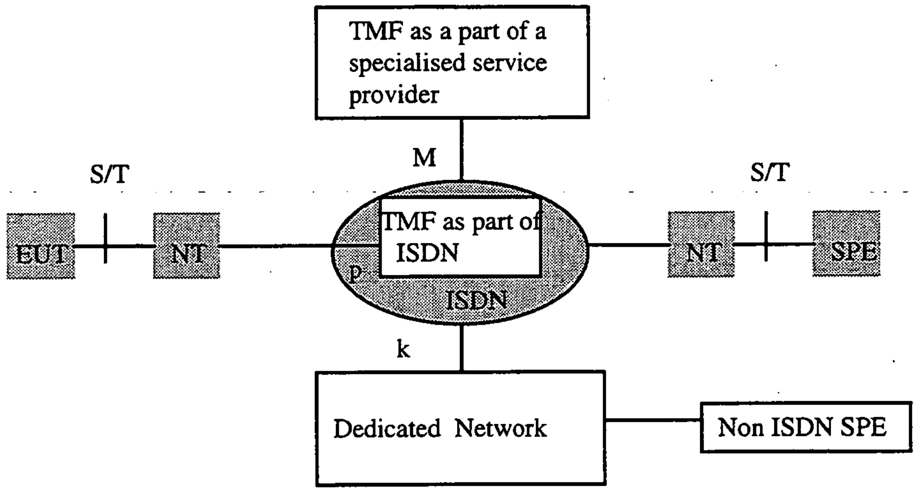


Figure 3.2

TMF (Teleaction Management Function)

The above model is based on the definition of teleaction functionality . This functionality implements some of the special properties required for teleaction services and is designated as the Teleaction Management function (TMF) .

The ISDN interfaces and referenec points are defined according to Recommendation I.324. The S/T reference points apply to any EUT ro SPE that has the standard ISDN user-network interfaces either Basic Rate Access(BA) or Primary Rate Access(PRA) . The TMF involves additional functionality that may be provided within or outside the ISDN and . The reference point between the ISDN and the TMF as designated as P if the TMF is implemented as an integrated specialized network resource , that may include high layer functions, and designated as M if the TMF functionality is provided by a specialized service provider. There are no implications for the end user by this architectural difference. In both the cases , the end-user terminal and service provider terminal access the basic ISDN network at reference point S or T. Dedicated networks may interwork if required with the ISDN .

Functions required from a Teleaction -oriented Message Delivery System are as follows

- Broadcast and grouping of messages.
- Delivery with priorities.
- Alternative routing in case of failure.
- Traffic logging for statistical and audit purposes.
- Protection against traffic overflow.
- Protection against message modification ,message deletion,disclosure of message content , and message replacement .
- Secure permanent monitoring of the terminal .
- Notification to service provider.

Example of an Architecture to Support ISDN Teleaction Services -

Figure 3.3 illustrates a possible implementation that supports teleaction services via ISDN. The TMF functionality is implemented in several physical locations in the network:

• The teleaction multiplexers are located in the local exchanges. The multiplexers are accessed by the EUT on the D channel . They perform a multiplexing function of the frames coming from many terminals to the 64-kbs/s circuits

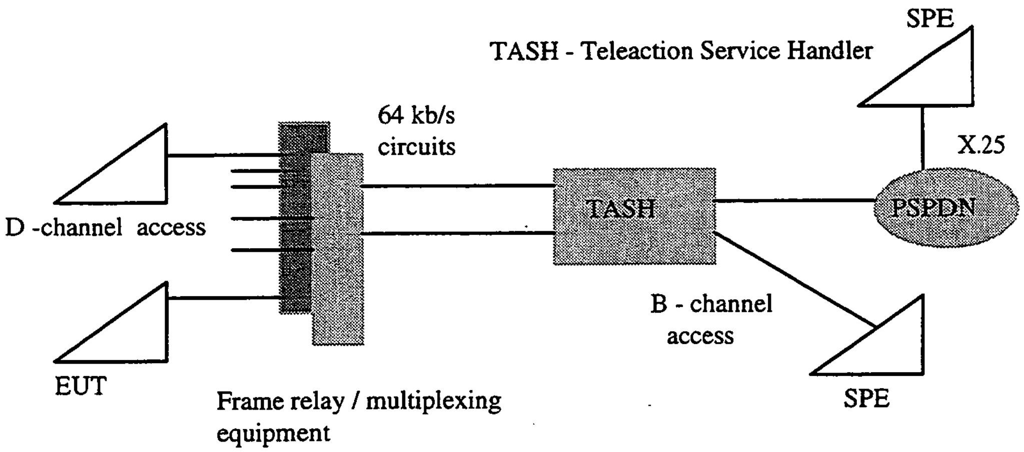


Figure 3.3

The multiplexers perform frame discrimination and multiplexing using the frame address information. The central teleaction server is connected to all the multiplexers and also has B channel connections to the SPE . The central server is used as the teleaction network manger and is used to remotely control the multiplexer equipment, to log the traffic data and to remotely load software to the multiplexers.

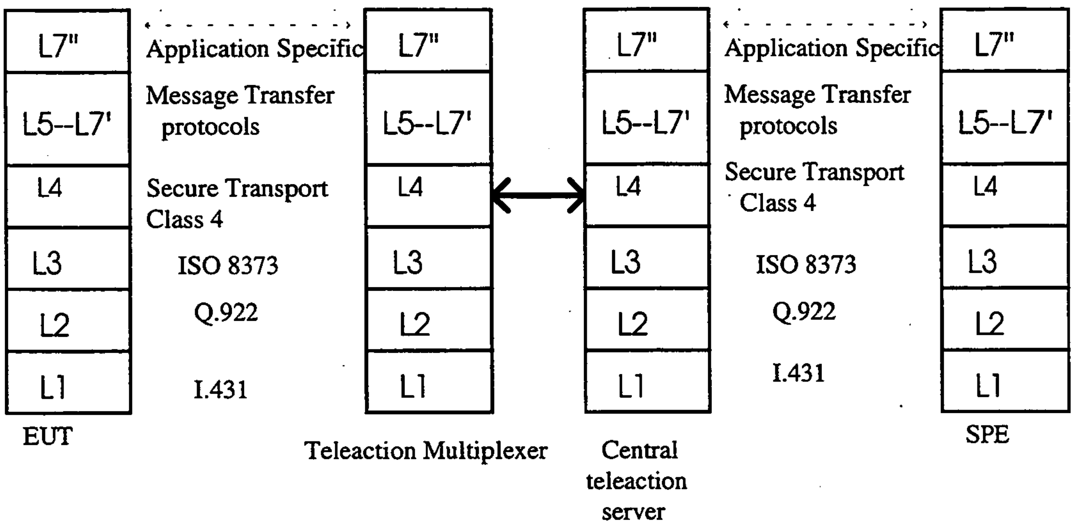
• In the example D channel access using a frame mode bearer service is used.It offers the advantage of some simplicity in the EUT and high efficiency in traffic utilisation . If the service provider operates through PSPDN or any other dedicated network , the Central server can perform some of the interworking functions (eg. protocol translation).

Figure 3.4 illustrates one possible deployment of the protocols in the system components. The use of connectionless network protocol can not itself guarantee reliable transfer of protocol data units. However it has the potential to reduce terminal costs and several teleaction servers may be deployed to reduce the traffic bottlenecks.

QOS - Quality of Service

Performance aspects of teleaction services are mainly concerned with the special requirements for end-to -end transit delay and system throughput.
Each service has special requirements . For example

• Transaction services: transit delay limits are mainly affected by the need to keep the user friendliness of the system (eg, 10 to 15 seconds response to cash out transaction). The system throughput should allow very high peak traffic.



Secure Transport Class 4 is defined in ISO 8073.

Figure 3.4

• Alarm services transit delay may vary from 10 seconds to several minutes depending on the alarm sensitivity . The throughput requirements should allow for peak hour traffic in the opening and closing of premises..

• Overall response time: Overall response time is the accumulation of all relevant delay components of the teleaction system. For example in electronic fund transfer , the overall response time includes : processing delay in the Automatic Teller Machine , transmission delay in the teleaction network(may include ISDN, PSPDN) and processing delay in the financial institution equipment.

• Fault report delay: the period from the time a fault information is reported to the monitoring system.

3.6 Frame Relaying On The D Channel To Perform Multiplexing Of Teleaction Data.

Recommendation X.31 has defined ISDN support of packet mode terminals for the maximum integration scenario using both D and B channel access. D channel access allows several X.25 DTE's to operate simultaneously by using address discrimination on layer 2. The accessed entity is a Packet Handler (PH) which is able to support X.25 Packet Level Procedures . By integrating the Teleaction Service Handler(TASH) into the ISDN we can consider the configuration depicted in the figure 3.5 as maximum integration scenario.

I.122 procedures are used between the terminals and the network and between the TASH and network. As teleaction service provider could operate in PSPDN the TASH could perform protocol conversion if needed . In this case the TASH is the Inter Networking Unit (IWU) between the ISDN and the X.25 networks.

Currently recommendation X.31 defines the protocol and functions of packet handlers to support X.25 DTE's. However , other layer 3 protocols should be considered for the teleaction service terminals. The connectionless Network service (CLNS) could offer simplicity in implementation

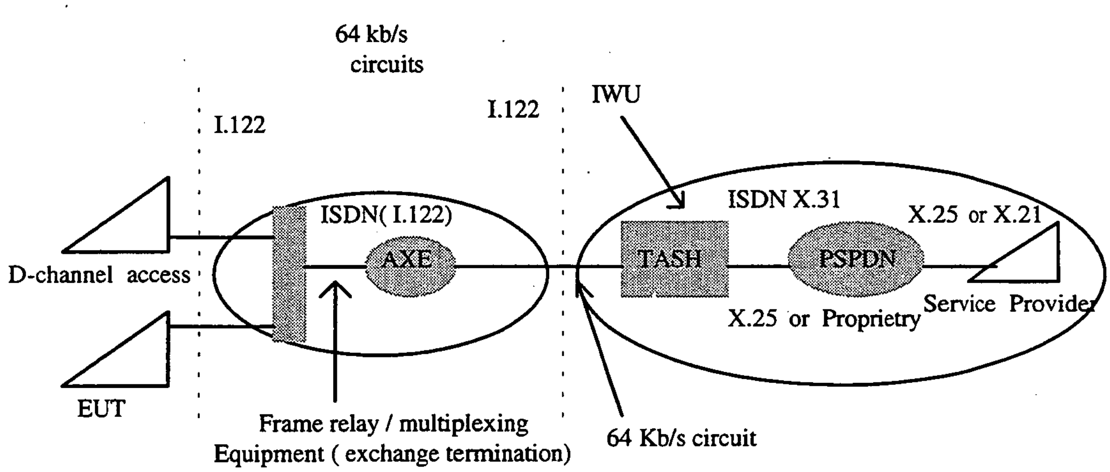


Figure 3.5

I.122 procedures operate on the links between the terminals or the service providers and the frame relay / multiplexer is considered to be a part of the functional group of the Exchange Termination(ET).

The figure illustrates the connection of a frame relay multiplexer to the TASH via 64kbps circuit connections . These connections could be switched or semipermanent and would be offered over the B channel. Concentration of data from hundreds of terminals should be done in order to utilise the

64kbps.circuit.ISDN basic access would be connected to the TASH usually via the D channel.

The Teleaction Service Handler (TASH)

The functions that teleaction service handler should support are all the functions outlined in the section 3.2. Also it is clear from the protocol layer architecture that the application layer is subdivided into two sublayers : application specific and teleaction message transfer specific.

• The secure transport class 4 service supports the following functions : secure message delivery , permanent monitoring , protection against disclosure of message content , alternative routing . By supporting these functions the implementation of the higher layers is simplified to the minimum necessary, if any.

The TASH could be connected to the service provider or to another TASH. The transmission medium could be an ISDN D channel. The links between TASH's and service provider are less vulnerable than the link between the terminal and the TASH. Furthermore , the traffic which is carried via these links should be minimised in order to reduce traffic costs.

• session layer protocol - the functionality of the session layer is considered to be unsuitable for the teleaction type of traffic which has very short messages , a fast response requirement and simple dialoge between applications.

• Presentation layer - the functionality of the presentation layer is supported by the message transfer sub-layer and the application layer .

• Teleaction message transfer layer - broadcast priority and message routing to an alternative service provider are some of the many parameters that are usually used for conventional message services. The addition of other parameters to the message header should be carefully considered as the length of the header should be minimised. Traffic logging for audit purposes is considered as an essential feature of teleaction service.

Chapter 4

APPLICATION OF ISDN D CHANNEL FOR ELECTRONIC FUNDS TRANSFER AT POINT OF SALE.

These applications can be thought of as major commercial applications of teleaction teleservices. Already these applications are in use in many countries. These applications are currently provided using X.25 protocol for communication. In some places they are provided using leased line facility.The later one is comparatively costly . Following is an example of " Credit card authorisation at the point of sale".

A busy merchant can use ISDN to get credit card authorisation in significantly less time. The merchant does not lose customers because of long waits in line. Figure 4.1 shows the configuration .(Bell Core. U.S.A.)

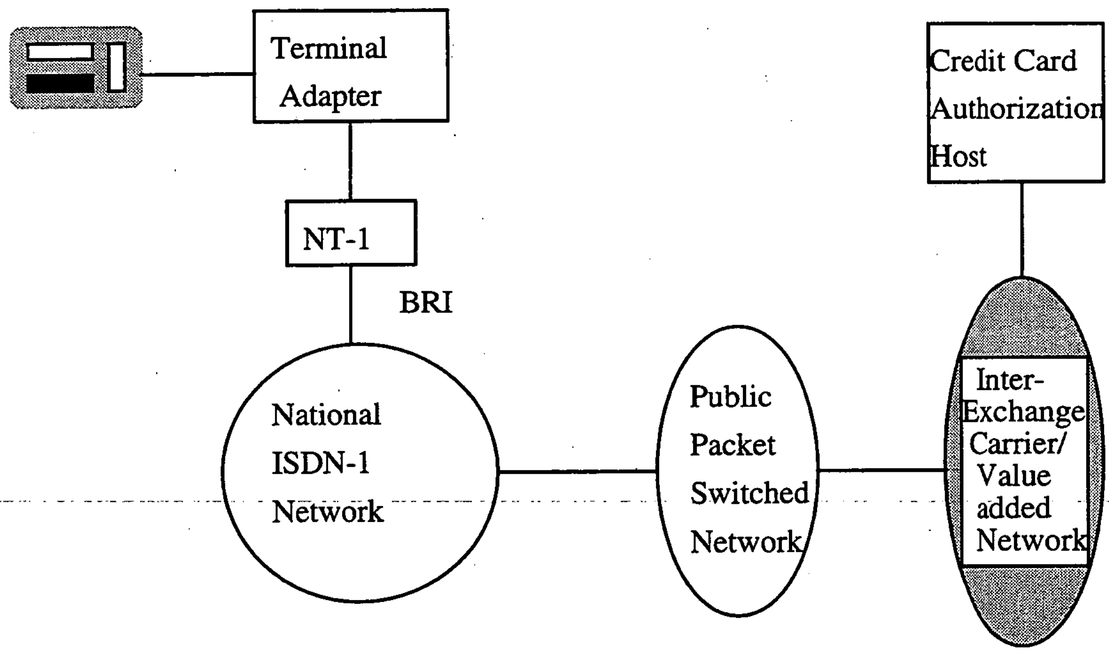


Figure 4.1

When credit card verification is needed , the Terminal Adaptor reads the transaction data from the card reader and sets up a 9600 bps D channel packet-data call to the Credit Card Authorisation (CCA) Host. After the CCA Host Answers , the TA and Host exchange data packets containing transaction information. When the transaction is completed , the call is cleared.

4.1 Functional Requirements

A transaction involves a number of actions and data I/O operations:

- display of instructions and error messages on the ATM
- input from the magnetic card reader
- input from the keypad
- authentication of the user via PIN number (using keypad)
- amount of money involed in transaction
- approval of transaction
- identification of ATM machine (card reader)
- commands to ATM machine to accept deposits, dispense cash and issue statement dockets, swallow credit cards etc.
- start up and shutdown the ATM

The operation of the system , currently using X.25 for communication, requires

- A high degree of reliability (low error rates, error protection)
- availability of almost 100%
- short response time (to/from remote host)
- graceful exits from error conditions which may arise during any stage of the transaction (local ,remote or comm link failures)
- security (more important with X.25 than with leased lines)
- secure encryption of PIN numbers etc.

4.2 Interface to ISDN

Here in this application , we have to interface non-ISDN equipment on ISDN. Terminal Adaptor is used as the interface. ISDN terminal adaptor should support the following services.

- D channel capabilities

- packet data on the D channel .
- If using Narrow Band ISDN , support for packet- data Directory Number (with fixed TEI) will be needed.
- Packet Assembler & Disassembler(PAD) function , supporting X.3,X.28,X.29 and possibly T3POS (Transaction Processing Protocol for Point-of-Sale - is a credir card verification protocol that optimises transactions over X.25 networks

including ISDN and is based on VISA protocol and ISO Basic mode control procedures. T3POS can be found in Bellcore document SR-NWT-002026) , depending on service provider.

- Support for the packet- data features listed under " Network Interface to ISDN Terminal Adaptor".

• Physical interfaces:

- Serial connection to Personal Computer (eg.,RS-449)

-RJ-45 connector to NT-1 or integrated NT-1

• Packet Data Features:

    -logical channels: At least 1 Two-Way LC

    -Default Throughput Class: 9600 bps

    -Maximum User Data Field : 128 octets.

    -Packet Window Size: 2

    -Closed User Group Security.

The T3POS (" Transaction Processing Protocol for Point-of-Sale") TA uses a Two-Way Logical Channel because transaction processing is a two way communication. For example the transaction proceses begins when the customer inputs the PIN number on the keypad. This PIN number is varified at the CCA host database and a confirmation is sent back. Transaction proceeds only after the reception of confirmation. Also the CCA (Credit Card Authentication) host can also place packet-data calls to the Card Reader at the end of the day to varify the total transaction.

4.3 Advantages of application of ISDN D channel for credit card verification at the point-of-sale **(Reference Bellcore Communications)**

• Each location is permanently connected: Every D-channel terminal has its own Host ID or Data Network Address. It means that X.25 e-mail and messages can be sent directly to another location rather than to a mailbox for later retrieval.

It offers:

• High-speed permanent access. Because point-of-sale terminals are linked directly to the packet network, there need be no dialling, no waiting. Credit authorisations and other transactions that once took 12-45 seconds are now routinely done in 2-4 seconds.

• Low access and transmission costs. In addition to basic ISDN line charges, access to the packet network costs $4(US) a month for each D-channel device. Up to eight data devices can share, and simultaneously use, the D channel.

•Transmission costs through the packet network are based on the amount of data transmitted, not time or distance.

• Assured accuracy. Because POS(point-of-sale) devices range from outdoor gasoline pumps to supermarket card-swipe machines, and because everything from wind-driven rain to dripping ice cream cones must be accommodated, the error-checking/error-correction capabilities of X.25 again offer a major advantage. Credit verification is a perfect example of an application where call-connection performance is much more important than raw transmission speeds.

• High-speed transactions. Since the typical point-of-sale/point-of-service transaction contains less than 100 total characters, even the largest takes less than a tenth of a second to transmit. Full POS transactions from the card swipe to credit authorisation are most often completed in two to four seconds.

• Simple, easy equipment configuration. Many ISDN telephones and terminal adaptors come equipped with a standard RS232 jack, and contain their own packet assembler-disassembler (PAD). The same RS232 connection is most often used by the majority of today's non-ISDN data devices.

•Telephones, too. Each ISDN BRI connection supports any combination of up to eight telephones, faxes, PCs and other terminals, and lets any two of these B-channel "conversations" go on while transactions occur in the background

4.4 Packet Data Call Setup and Clearing on D channel.

The Figure 4.2 shows the signalling flow for Packet-Data Call Setup and Clearing for D channel Packet-Data Terminals.

Some of the specifications used for credit card authorisation - application in USA are given below (Bellcore).

• The T3POS uses a Two-Way Logical Channel because the CCA Host can also place packet -data calls to the Card Reader (e.g. at the end of the business day to download a record of all credit card transactions received that day.)

• Simultaneous Vice and Data: Voice calls can be placed and answered using the B channel while credit -card transactions are performed on the D channel (A voice Directory Number and Service Profile Identifier are needed for the phone) .

• In cases where the data exchange between the TA and the Host involves 128 octets or less in each direction , Fast Select can be used instead of a complete X.25 call . If Fast Select is used the TA interface must also be subscribed to the Fast Select and Fast Select Acceptance features.

Calling User Interface . . . . . Network . . . . . . Called User Interface

Calling User Interface	Called User Interface
Packet Mode Data Call (TEI 3 , DN 3)	PMD Call (TEI 6, DN 6)
Call Request →	Incoming Call →
Logical Channel Number=1 Calling Party Address=DN 3 Called Party Address=DN 6	LCN=1 Calling Party Address=DN 3 Called Party Address=DN 6
	Call Accepted ←
Call Connected ←	LCN=1
LCN=1	
Data →	Data →
LCN=1	LCN=1
Data ←	Data ←
LCN=1	LCN=1
Clear Request →	Clear Indication →
Clear Confirmation ←	Clear Confirmation ←

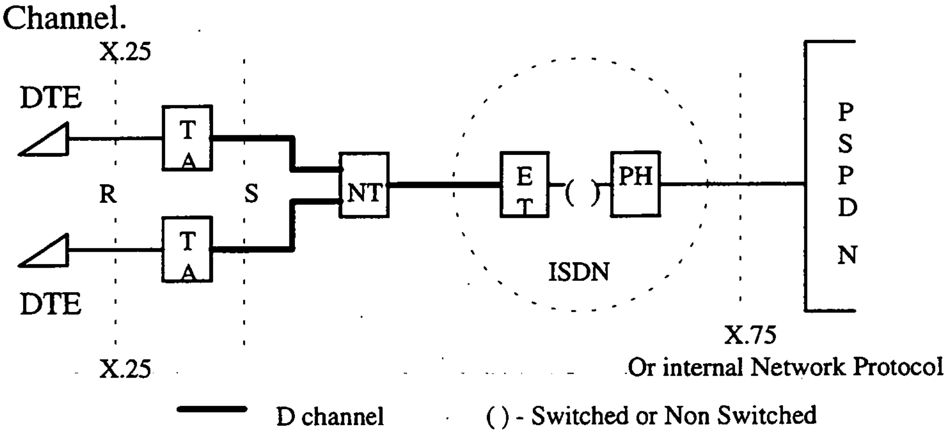
Fig 4.2

• In many cases the packet- data configuration of the TA and CCA Host (and the intermediate X.25 network) will not be the same. As a result , the likelihoodof packet-data call completion will be higher if the TA and its packet-data DN also support Throughput Class Negotiation and Flow Control Parameter Negotiation.

• Closed User Group (CUG) is used here to provide the Card Reader and the CCA Host with access security . If the card reader needs to access multiple CCA Hosts , the Card Reader's DN will have to belong to multiple CUGs(eg one CUG for each Host), and will have to support CUG Selection so that the TA can select the Host's individual CUG on a per-class basis. Host may also use screening of the Card Reader's X.25 Calling Party Address to enforce access security.

• The interface between the card reader and the TA can support either X.28 or T3POS protocol. .

Figure 4.2 shows the architecture for use of Packet Data Over D Channel.



CCITT I.462

Figure 4.3 (Maximum Integration scenario -access via D channel - I.462)

4.5 Inroduction to Hardware Design

The concept of the Integrated Services Digital Network(ISDN) originated from the desire to provide integrated services through better use of the bandwidth potential in existing telecommunications subscriber loops . Advaces in VLSI technology and digital signal processing have made high rate digital transmission to the subscriber not only possible , but also economical One of the cornerstones of the ISDN concept is international compatibility .The CCITT has addressed this requirement by defining a rigid structure for subscriber access to an ISDN , at several reference points. We have seen this architecture in chapter2.

The implementation of an economical ISDN requires a number of principle interfaciing and support functions to be performed by VLSI devices . These functions are :

a) Interfacing to the U reference point.

b) Interfacing to the s0,s1 and s2 reference points (s1 and s2 correspond to Primary Rate Interface).

c) Interworking with non-ISDN (RS-232, x.21) formats at the R refence point

d) Voice coding /decoding

e) Link layer and network layer communication

f) Circuit switching

g) Time base generation

To be considered complete , a family of ISDN components must support of all these ISDN functions. Mitel semiconductor provides components for each of these functions. all connected by the ST-BUS component interface.Table 4.1 shows the family of Mitel Semiconductor components which provide ISDN compatiblity. All the component specfications and design guidelines used in this section are in reference to "Digital Communications Handbook" from Mitel Semiconductor Devices.

ISDN Function	ST -BUS Component
U Inreface	MT 8930(DNIC)
S0 Inrercae	MT 8930(SNIC)
S1 Interface	MT8978,MH89780
s2 Interface	MT8976
Non-ISDN Data Interface	MH89500(Rate Adaptor)
Voice Codecs and Digital Telephone	MT8964/65 and MT8994/5
Link Layer Support	MT 8930
Switching	MT8980/81

Timebase Generation	MT8940

Table 4.1

4.6 Design Of Interface **For point of sale application**

As we have seen already point of sale application has a card reader at the user premises. This is a Non ISDN equipment. We need a terminal adaptor to provide the interface. The other components are selected to meet the user network interface standards. Figure 4.3 is the overview of system design.

In this section, we deal with Mitel Interface circuits in brief, then a detailed discussion about every Mitel component used in this report is given. As discussed earlier, ISDN basically deals with bottom 3 layers of the OSI reference model.

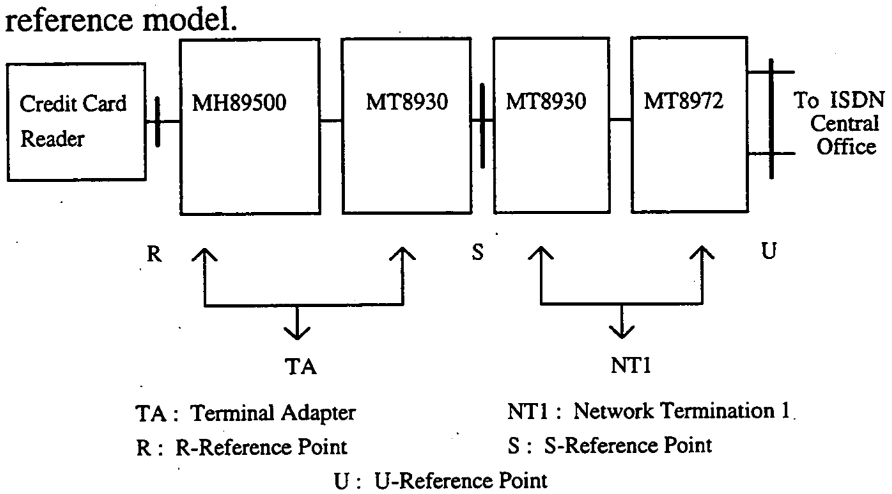


Figure 4.4

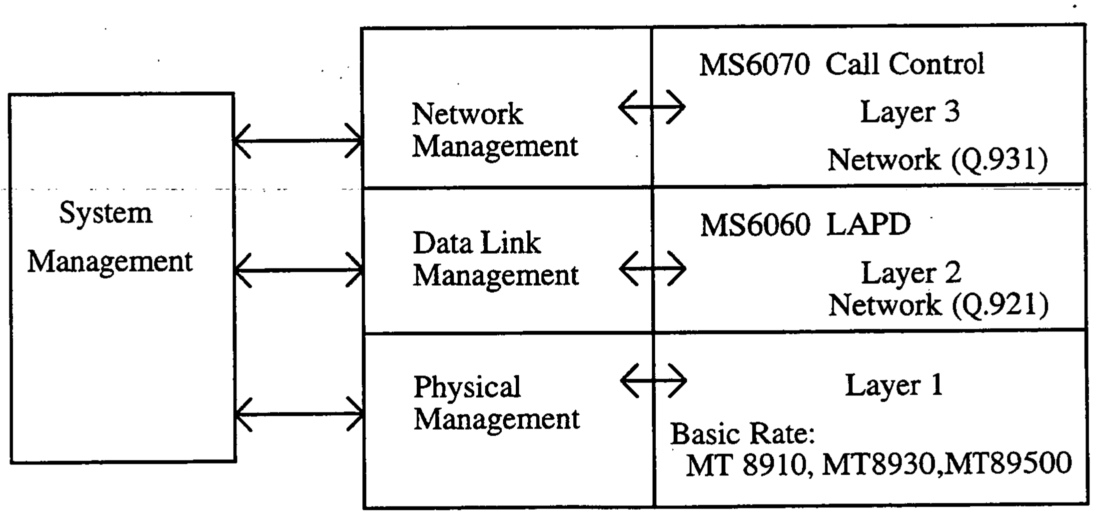


Figure 4.5 *Mitel ISDN Signalling solution*

4.7 Physical Layer

As shown in the MITEL ISDN signalling solution *figure 4.4*, a detailed summary of structure, functional requirements and hardware implementation is given from physical layer to network layer respectively

4.7.1 R- Interface Module (*MH89500 chip*)

Main application of *MH89500* are as

1. Terminal Adaptors for ISDN.
2. Subrate Digital Multiplexers (SDM's).

The *MH89500* R-Interface module(RIM) is a circuit which implements the rate adaptation, the frame formatting and the data transfer functions of an ISDN Terminal Adaptor confirming to recommendation I.461 & I.463. It converts data between the interface formats of an ISDN B-channel and a terminal port, confirming to V.24, X.20 or X.21.

The RIM will function back to back with Mitel's MT8930 SNIC (S/T interface) to provide a complete terminal adaptation solution between V or X series ports and the ISDN S/T interface. The user port is programmable to synchronous or asynchronous operation at several different data rates. The network port may be configured in different timing positions, one of which is ST-Bus compatible. A parallel port on the device provides access to RIM status and control information. This port may be configured as a microprocessor peripheral interface or in a standalone mode.

The SNIC (Subscriber Network Interface Circuit) MT8930 can be combined with the MH89500 R-Interface Module (RIM) to form an ISDN Terminal Adaptor as shown in *Figure 4.5*

About the pins used in the respective chips of Terminal Adaptor.

RIM : *MH 89500*

1. TxD(Pin number is 2) : Transmit Data (Input) - This is the serial data input from the DTE. Data is transmitted from the least significant bit to high significant bit. Polarity is logic high = 1 = MARK

2. RxD(Pin number is 3) : Receive Data (Output) - This is the serial data output to the DTE. Data is transmitted from the least significant bit to the high significant bit. Polarity is logic high = 1 = MARK.
3. DSTi(Pin number is 16) : Network Receive Data(Input) - Serial data from the network in the rate adapted frame format is received on this pin during bit times specified by registers SEL1 and SEL2. Data is received from least significant bit. Polarity is logic high = 1.
4. DSTo(Pin number is 15) : Network Transmit Data(Output) - Serial data in the rate adapted frame format is output to the network port on this pin. This output is high impedance outside of the active bit times specified by registers SEL1 and SEL2. Polarity is logic high = 1.
5. $\overline{\text{F0i}}$ (Pin number is 18) :Network Frame Pulse(Input) - This input indicates the beginning of channel 0 on DSTo and DSTi. The format of the required input is selected by bits 5,6 and 7 of selection register SEL2.
6. $\overline{\text{F0o}}$: (Pin number is 19) : Cascade frame pulse(Output) - This signal goes low at the end of channel 0 on DSTo and DSTi straddling an active edge on $\overline{\text{C4i}}$

The microprocessor is responsible for rate converting the RS-232 data from the credit card reader to the existing ISDN standard.

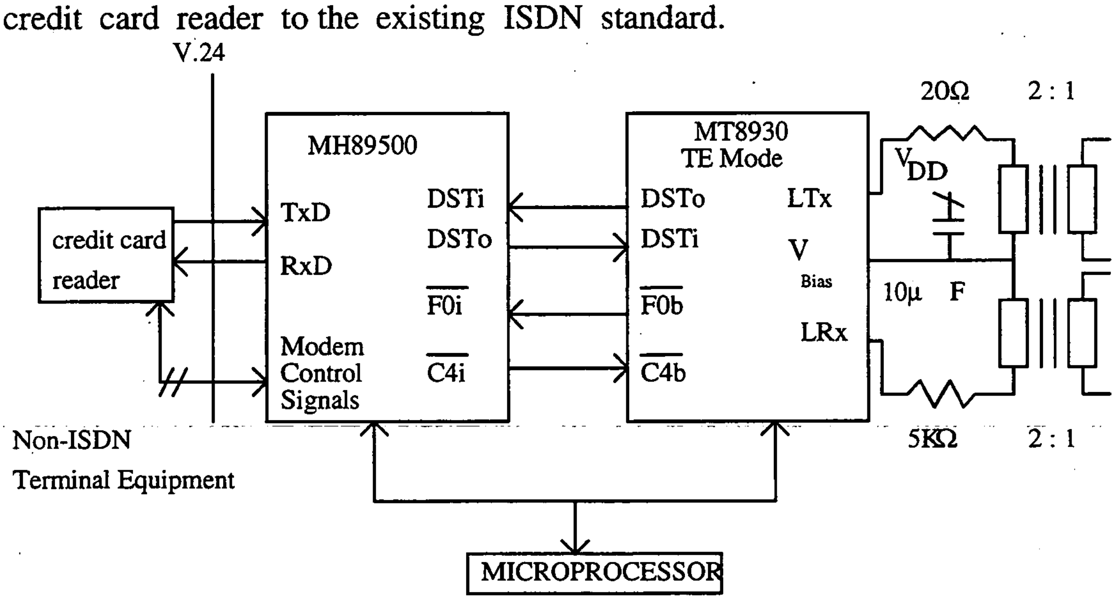


Figure 4.6 *ISDN Terminal Adaptor*
Rate Adaptation Scheme

The bit rate adaptation function within the RIM is divided into three blocks are labelled as RA0, RA1 and RA2.

The function of RA0 is an Asynchronous to Synchronous conversion stage. It is only used with Asynchronous user interfaces at data rates greater than or equal to 600 bits/sec.

RA1 converts the RA0 output or the users synchronous data to an intermediate data stream.

RA2 performs the final conversion from the intermediate rate to a 64 Kbits/sec, ISDN's B-channel.

Bit Position Number

Octet #	1	2	3	4	5	6	7	8
0	0	0	0	0	0	0	0	0
1	1	D1	D2	D3	D4	D5	D6	S1
2	1	D7	D8	D9	D10	D11	D12	X
3	1	D13	D14	D15	D16	D17	D18	S3
4	1	D19	D20	D21	D22	D23	D24	S4
5	1	E1	E2	E3	E4	E5	E6	E7
6	1	D25	D26	D27	D28	D29	D30	S6
7	1	D31	D32	D33	D34	D35	D36	X
8	1	D37	D38	D39	D40	D41	D42	S8
9	1	D43	D44	D45	D46	D47	D48	D49

Table 4.2*Frame Structure*

The RIM generates an 80 bit frame as shown in *Table 4.1*. The order of transmission is from left to right and top to bottom, least significant bit first. Octet zero contains all zeros and bit one of other nine octets contains binary 1. Theses bits make up a 17 bit frame alignment pattern. The frame alignment pattern is used to achieve frame synchronization between Terminal Adaptors.

The D-bits carry the information that is received and transmitted on the user port pins TxD and RxD. The function of S and X status bits depend upon what state the RIM is in. The E-bits are used to carry the user rate information in bits E-1 to E-3, network independent clock information in bits E-4 to E-6, and multiframe synchronisation information for 600 bits/sec user rate on bit E-7.

User Port Interface:

The user port interface includes TxD, RxD, $\overline{RTS}, \overline{CTS}, \overline{DSR/I}, \overline{DTR/C}, \overline{DCD}$, and USRCLK which make up the DCE interface and RA1CLK, 20RA1/8RA0CLK, TxD24, RxD24 and $\overline{EWR}$ which are provided for network independent clocking. The interface circuits on the MH89500 are labelled as DCE signals to provide a standard DTE to DCE connection.

Network Port Interface:

The Network Port Interface consists of NTxD/DSTo, NRxD/DSTi, It provides the interface between the RIM and a digital network interface device.

Parallel Port Interface

The parallel port includes A0-A1, D0-D7, PWD/$\overline{CS}, \overline{RD}, \overline{WR}, \overline{INT}$ which have their operation controlled by the mode of the port, LOOP, SYNC and RUN, which provide continuous status information. It may be initialised to run either in peripheral or standalone mode. In peripheral mode the parallel port is configured as a microprocessor peripheral. Standalone mode allows the RIM to run without the microprocessor.

An active low on $\overline{RST}$ sets the PWD and DISC bits in the SEL1 to 1. The low to high transition on $\overline{RST}$ is used to latch the state of PWD/$\overline{CS}$ to select the mode of operation when the RIM comes out of RESET. Following *table 4.2a* shows the mode selection.

MODE	ACTION	PWD/$\overline{CS}$	$\overline{RST}$
X	RESET	X	0
X	Initialise Standalone Mode	0	↑
X	Initialise Peripheral Mode	1	↑
Standalone	Power down	1	1
Standalone	Normal	0	1
Peripheral	Enable Databus	0	1
Peripheral	Tristate Databus	1	1

↑ : indicates a logic low to logic high transition

Table 4.3a

Depending on whether the credit card reader is microprocessor controlled or not, we can have either a peripheral or standalone mode of operation respectively. In this paper, this chip is used in peripheral mode.

In standalone mode the $\overline{RD}, \overline{WR}$ and A0-A1 pins are all configured as outputs. The RIM generates pulses on the $\overline{RD}$ and $\overline{WR}$ pins to indicate whether data is output from or latched into the RIM. Addresses corresponding to registers SEL1-SEL3 and EBIT are output on A0 and A1 during four consecutive $\overline{WR}$ strobes. Data appearing on D0-D7 at the time of each $\overline{WR}$ strobe is latched into the appropriate register, thus setting up the various RIM operating positions and loading the E-bits for transmission over the network. The received E-bit word in the ESTAT register and the STAT1 register are output on D0-D7 with two $\overline{RD}$ strobes. The data may be latched on the rising edge of $\overline{RD}$. The interrupt ($\overline{INT}$) pin is disabled and its output is forced high. The PWD/$\overline{CS}$ input is configured as powerdown(PWD). A logic high on this pin puts the RIM into the powerdown state.

When peripheral mode operation is selected, the PWD/$\overline{CS}$ pin is configured as a CHIP SELECT ($\overline{CS}$) and the $\overline{RD}, \overline{WR}$ and A0-A1 pins are all configured as inputs. A0-A1 select the appropriate register and $\overline{CS}$, along with a $\overline{RD}$ or $\overline{WR}$ strobe, controls when the data is presented from or latched into the RIM on D0-D7. The $\overline{INT}$ pin is enabled and is driven active when the sync bit in the STAT1 register changes. The state of the SYNC bit is frozen until the STAT1 register is read. The $\overline{INT}$ pin is cleared and the current SYNC status is loaded into the register. If the status has changed again a new interrupt will be generated. The contents of STAT1 may be monitored by the external pins RUN, SYNC and LOOP but this will not clear the interrupt condition.

Reset/Powerdown operation

An active low on $\overline{RST}$ sets the powerdown and disconnect bits in SEL1 register to 1. The low to high transition on $\overline{RST}$ is used to latch the state of PWD/$\overline{CS}$ to select the mode of operation of the parallel port. Following RESET the RIM will be in the powerdown state, if it is initialised to peripheral mode and in the idle state of the data transfer sequence if it is initialised to standalone mode.

In powerdown the user and network ports are disabled but the parallel port is still active. The outputs on the network port are all tri-stated. When powerdown is removed, the RIM will enter the idle state.

REGISTERS

The accessible registers and their associated addresses are given in the following table.

Register Address Decoding

$\overline{RD}$	$\overline{WR}$	A1	A0	Register Description
0	1	0	0	STAT1. Status register
1	0	0	0	SEL1. Options selection
1	0	0	1	SEL2 Options selection
1	0	1	0	SEL3. Options selection
1	0	1	1	EBIT. Transmit E-bits
0	1	1	1	ESTAT. Received E-bits

Table 4.3b *STAT1 Register*

The STAT1 register provides data transfer state and device status information. The three status bits may be monitored on external pins, RUN, SYNC and LOOP. In peripheral mode, a change in the SYNC bit will cause an interrupt. The status of the SYNC bit will be frozen until the register is read. The current status will be loaded into the register after the read.

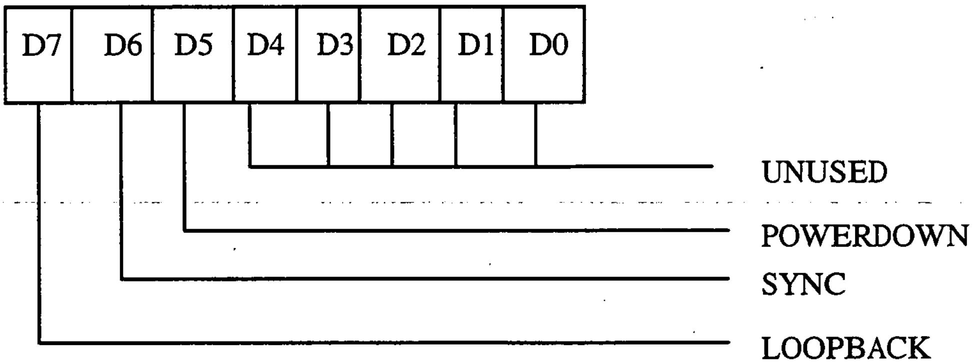


Figure 4.7 *STAT1 Register*

The status bits indicate the following :

LOOPBACK (Bit 7) : A HIGH on this bit indicates that either a remote or a local loopback is in operation. A low indicates no LOOPBACK.

SYNC (Bit 6) : This bit is set HIGH to indicate that the RIM has achieved frame synchronisation with the incoming network data. A low indicates loss of frame synchronization.

$\overline{\textit{POWERDOWN}}$ (Bit 5): This bit is reset LOW to indicate that the RIM is powerdown mode. A HIGH indicates that the RIM is running normally.

SEL1 Register

Selection register 1 (SEL1) is a write only register which is used for general purpose control of the RIM. The bits contained in this register and their functions are described as follows :

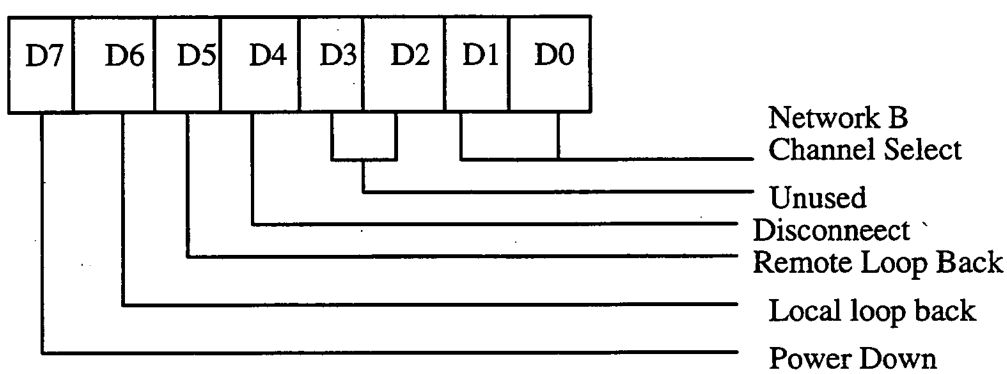


Figure 4.8 *SEL1 Register*

POWERDOWN (Bit 7) : When set HIGH, this bit forces the RIM into powerdown mode. When LOW the RIM is allowed to run normally. This bit allows the RIM to be put into the powerdown mode while it is in the peripheral mode. It is inactive when the RIM is in standalone mode.

LOCAL LOOPBACK (Bit 6) : This bit, when set HIGH , causes NTxD/DSTo to be looped back to NRxD/DSTi to the user port. This loopback overrides the remote loopback selected by bit 5 and may be used to debug the connection to the RIM's user port. DISC (bit 4) must be set high for loopback to operate. A LOW on bit 6 allows normal operation.

REMOTE LOOPBACK (Bit 5) : When set HIGH, this bit causes RxD to be looped back to RxD to be looped back to TxD to the network port. This loopback may be used to debug the connection to the RIM's network port. DISC (bit 4) must be set HIGH for loopback to operate. A LOW on bit 5 allows normal operation.

DISCONNECT (Bit 4): Setting this bit to 1 while the RIM is any state initiates a disconnect sequence, returning the RIM to its idle state. Resetting this bit to 0, while the RIM is in idle state causes the RIM to begin its data transfer connection sequence.

NETWORK B-CHANNEL SELECT (Bits 0-1) : Setting these bits according to the following table will select the channel on the network data ports which the RIM will consider the B channel. NTxD/DSTo will be tristated during all other channels. When selecting channel P there must be atleast P+1 channels in the network frame.

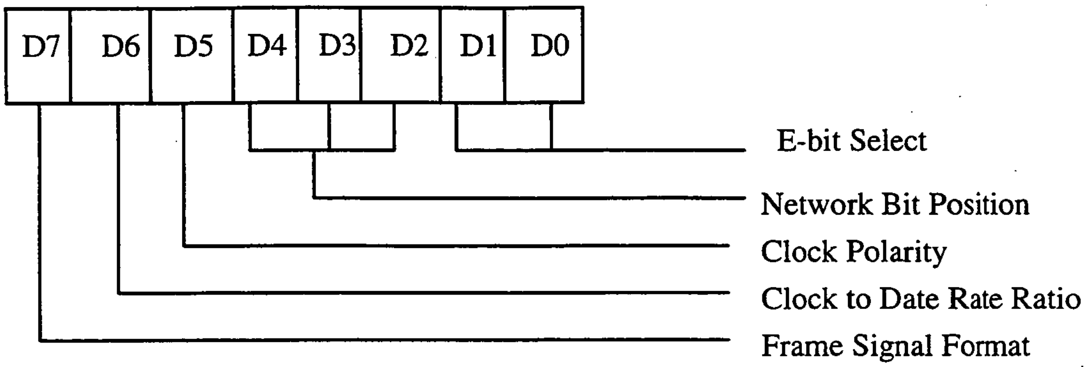
D1	D0	
0	0	Channel 0
0	1	Channel 1
1	0	Channel 2
1	1	Channel 3

Network B - channel Select Programming

Table 4.4

SEL2 Register

Selection register 2 (SEL2) is a write only register which is used to program network interface options of the RIM. The bits contained in this register and their functions are described below.



SEL2 Register

Figure 4.9

Frame Signal Format (Bit 7) : This bit specifies what timing state will indicate the beginning of the network frame. A HIGH on this pin will cause the RIM to start the network frame on a logic low to high transition on NFRM/$\overline{F0i}$. This transition must be aligned with an active edge on NCLK/$\overline{C4i}$. A LOW will cause the RIM to start the network frame when an active edge on NCLK/$\overline{C4i}$ occurs while NFRM/$\overline{F0i}$ is logic LOW. The frame time period must be 125 μ sec in either format.

Clock to Data Rate Ratio (Bit 6) : When this bit is HIGH the RIM will transmit and receive data on the network data ports at the same rate as the network clock (NCLK/$\overline{C4i}$). One clock period equals one bit time. when this bit is LOW the network data rate is half the network clock rate. Two clock periods equal one bit time.

Clock Polarity (Bit 5): A LOW on this bit specifies that a low to high transition on $\overline{C4i}$ will be considered the active edge of the clock. A HIGH specifies the high to low transition as the active edge. The active edge determines the bit boundaries of the network data.

Network Bit Position (Bits 2-4) : These three bits select the first active bit position in the B-channel on the network data ports as given in the following table. The number of active bits is determined by the RA1 subrate. The first bit position, P, and the number of bits, N, must be selected so that P+N <= 8.

D4	D3	D2	
0	0	0	Bit 0
0	1	1	Bit 1
0	1	0	Bit 2
0	1	1	Bit 3
1	0	0	Bit 4
1	0	1	Bit 5
1	1	0	Bit 6
1	1	1	Bit 7

Table 4.5 *Network Bit Position Programming*

E-bit Select (Bits 0-1) : Setting these bits according to following table selects the E-bits that will be transferred from the EBIT register to the E-bit octet in the rate adapted frame. Non selected bits are sourced automatically by the RIM.

D1	D0	
0	0	Unused
0	1	E4, E5, E6
1	0	E4, E5, E6, E7
1	1	E1,E2,E3,E4,E5,E6,E7

Table 4.6 *E-bit Select Programming*

SEL3 Register

The selection 3 register (SEL3) is a write only register which programs the user interface options. The register bits and their functions are as follows :

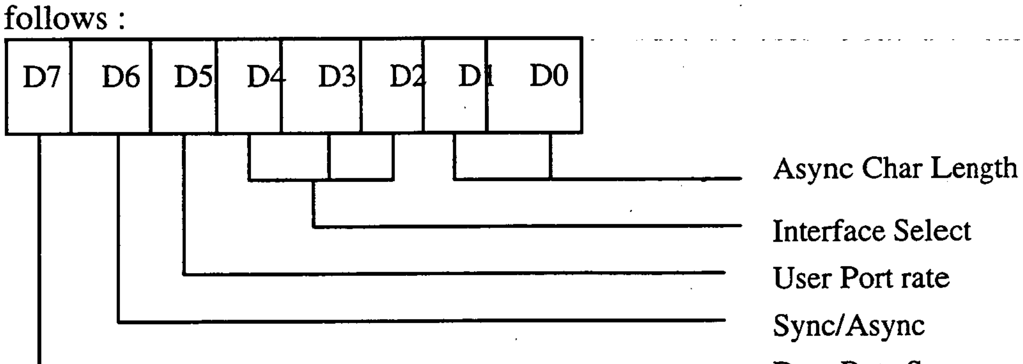


Figure 4.10 *SEL3 Register*

Data Rate Source (Bit 7) : When this bit is low the user port data rate is selected by writing to bits 3-5 of this register ($SEL3_b3$-5). When HIGH the user port data rate is selected by bits E1-E3 on the incoming rate adapted frame from the network.

Sync/Async (Bit 6): A high on this bit causes the user port to operate in synchronous mode while a LOW results in asynchronous operation.

User Port Rate (Bits 3-5): These bits select the user port data rate as per table given below when bit 7 of this register ($SEL3_b7$) is low. The user port data rate determines the USRCLK, the internal RA0 and RA1 clocks and the intermediate clock rate.

D5	D4	D3	
0	0	0	64 kbit/s Sync, Unused Async
0	0	1	19.2 kbit/s Sync, Async
0	1	0	9.6 kbit/s Sync, Async
0	1	1	4.8 kbit/s Sync, Async
1	0	0	2.4 kbit/s Sync, Async
1	0	1	1.2 kbit/s Sync, Async
1	1	0	600 bit/s Sync, Async
1	1	1	Undefined

Table 4.6 *User Port Rate Programming*

Interface Select (Bit 2): Setting this bit to HIGH, configures the user data port as an X-series interface. The RIM follows the data transfer entry/exit states as specified by I.461. When this bit is LOW the user data port is configured as a V-series interface. All the interface circuits are active and the RIM follows the data transfer entry/exit states as specified by I.463.

Async Char Length (Bits 0-1) : Following table specifies these bits select the asynchronous character length. Different character lengths are provided for different combinations of start, stop, data and parity bits in the user's asynchronous character.

D1 D0

0	0	9 Bits
0	1	Unused
1	0	11 Bits
1	1	10 Bits

Table 4.7 *Async Character Length Programming*

Ebit and Estat registers : The Ebit and Estat registers allow access to the E-bits in the rate adapted frame. The specific bits in Ebit which are transmitted on E1-E7 are defined by the contents of bits 0 and 1 of the (SEL2_b0-1). Ebit is written into to define the contents of the selected E-bits in the transmitted frame. The same data is sent on every frame until the register is reprogrammed. Bit 0 is sent as a one regardless of what is written to the Ebit register. The Ebits received from the network are read from ESTAT.

Data Transfer Sequence :

The RIM handles the data transfer entry/exit sequence. It changes the state of the user port control circuits and the rate adapted frame signalling bits automatically. Following table shows the condition of the interchange circuits and the signalling bits for each state.

After the RIM has been reset or after a data transfer exit sequence the RIM will be in the idle state (state 0). The network data pin, NTxD/DSTo, will be tristated and the user data pin , RxD will be logic high. Setting the disconnect bit in selection register 1 (SEL 1_b4)[1] to 0 will cause the RIM to begin to transmit rate adaptation frames on NTxD/DSTo and look for rate adaptation frames on NRxD/DSTi (state 1). The data bits and the S and X bits in the transmitted frame are set to binary 1. The user port remains unchanged. If the autobaud bit in selection register 3 (SEL3_b7) is 1 then the RIM will look for incoming rate adapted frames but does not transmit them. When it is synchronised it will read E-bits E1-E3 and determine the user data rate. The RIM will enter state *.

* This represents the 4th bit of selection register 1

The RIM enters state 2 when it has detected the frame synchronization pattern on the NRxD/DSTi. The SYNC bit in status register 1 ($STAT1_b6$) will toggle from 0 to 1, the S and X bits in the transmitted rate adapted frame will be turned ON (binary 0) and NRxD/DSTi will now be monitored for a received frame with the S and X bits ON. The received S and X bits ON indicate that the remote RIM is also in state 2. If the user port has been configured as a V-series interface ($SEL3_b2 = 0$) the RIM sets up for data transfer but delays turning ON the $\overline{CTS}$ pin for 24 user bit times (state 3). After the delay the RIM will enter the data transfer state (state 6). If the user port has been configured as an X-series interface ($SEL3_b2 = 1$) then the RIM will go directly to the data transfer state.

In the data transfer state (state 6) the D and S-bits in the transmitted rate adapted frame are carrying the TxD, $\overline{DTR}/\overline{C}\mathit{and}\overline{RTS}$. The D and S-bits in the received frame are output on the RxD, $\overline{DSR}/\overline{I}\mathit{and}\overline{DCD}$. $\overline{CTS}$ and the transmitted X-bits are ON.

Setting the disconnect bit ($SEL1_b4$) to 1 will cause the RIM to exit from the data transfer state. If the user port has been configured as an X-series interface then the RIM will go directly to the idle state. If the user port has been configured as a V-series interface then the RIM goes through an exit sequence. Setting $\overline{DTR}$ to low on a V-series interface will initiate the same sequence. In state 12 a disconnect indication is sent to the remote RIM (D-bits=0, S-bits OFF and X-bits ON) and to the user port. The remote RIM detects the disconnect indication and sends a confirmation by sending back the disconnect indication to the local RIM with the X-bits OFF and to the remote DTE with $\overline{DSR}/\overline{I}$ = logic high (state 14). The local RIM detects the confirmation then also goes to the state 14. Both RIMs do not go to the idle state until their disconnect bits are set to 1.

If the RIM loses synchronisation with the received rate adapted frame, it will attempt to resynchronize. A sync lost indication (X-bits OFF) is sent to the remote RIM (state 10). Meanwhile the DTE is allowed to continue to send data on the transmitted frame. The remote RIM will recognize the X-bits OFF and will turn OFF $\overline{CTS}$ to the remote DTE (state 8). The local RIM will attempt to resynchronise for three seconds. The next state depends on how the user port is configured. As an X-series device the RIM will proceed to the DCE not ready state (state A) where it turns OFF all control signals to the DTE. The remote RIM remains in state 8. The local RIM must regain sync or to be forced to exit the data transfer by setting the disconnect bit ($SEL1_b4 = 1$).

When 64 kbit/s synchronous data is selected the RIM transfers from the idle state directly to the data transfer when disconnect is set to 0. There is no sync detection. The RIM will return directly to the idle state when disconnect is set to 1.

4.7.2 Subscriber Network Interface Circuit *(MT8930 chip)*

MT 8930 SNIC

1. 28 pin DIP, 44 pin PLCC
2. Self contained VCO
3. Low power CMOS
4. Activation/deactivation state machine
4. On board HDLC controller which reduces software requirements and external components.
6. Multiple loopbacks.

The SNIC has three interface ports:

1. A 4-wire CCITT compatible S/T interface.
2. A 2048 Kbits/sec ST-BUS serial port.
3. A general purpose parallel microprocessor port.

Applications :

The MT8930 Subscriber Network Interface Circuit is a device which implements the CCITT I.430 recommendations. The SNIC MT8930 can be connected to Mitel's MH89500 R-Interface Module(RIM) to implement an ISDN TA, used to connect non-ISDN terminal equipment to the S-interface. An HDLC D-channel protocoller is included and controlled through Intel microprocessor port.A. Controllerless mode allows simple implementation of an NT1 function in conjunction with the MT8972 DNIC as shown in figure.

The SNIC MT8930 supports 192 Kbits/sec (2B+D+overhead) full duplex data transmission on a 4-wire balanced transmission line. Transmission capability for both B and D channels as well as related timing and synchronization functions are provided on the chip. The signalling capability and procedures necessary to enable customer terminals to be activated and deactivated form part of the MT 8930's functionality. The SNIC handles D-channel resource allocation and prioritization for access contention resolution and signalling requirements in passive line configurations.

The MT8930 is useful in a wide variety of ISDN applications. Being used at both the Network Termination (NT) and the Terminal equipment (TE) ends of the line.

The SNIC can be combined with MT8972 (DNIC) or the MT8910 (DSLIC) to implement an ISDN NT1 functions. The MT8930 is configured in the NT mode, acting as a master to the S-interface line, while MT8972 operates in a slave mode and derives its timing from the user interface line originating from the central office. If the SNIC is put in controllerless mode, then communication between two devices is done via the serial ST-BUS ports. Control and Status of the SNIC is communicated with the MT8972 through the C-channel of the ST-BUS.

Another application of the SNIC is its use with the MH89500 R-Interface Module (RIM) to form an ISDN Terminal Adaptor (TA) as shown in figure . A terminal adaptor is needed to provide conversion from a non-ISDN interface used by non-ISDN terminal equipment, to an ISDN S-interface used by ISDN terminal equipment.

Both the MT8930 and MH89500 are controlled and monitored by a microprocessor to implement various features and control functions. The microprocessor is responsible for rate converting the RS-232 data..

MT 8930 PINS

DSTo(Pin No 6) : Data ST - BUS Output : a serial PCM/data ST-BUS output with D, C, B1 and B2 channels assigned to the first four time slots respectively. The remaining timeslots are placed into high impedance. These channels contain data received from the line and chip status information.

DSTi(Pin No 5) : Data ST - BUS input with D, C, B1 and B2 channels assigned to the first four time slots. These channels contain data to be transmitted on the line and chip control information.

$\overline{\text{F0b}}$(Pin No 3) : Frame Pulse an active low frame pulse input indicating the beginning of active ST-BUS channel times in NT mode. Frame pulse output in TE mode.

$\overline{\text{C4b}}$(Pin No 2) : a 4096 KHz ST-BUS Data Clock input in NT mode.

In TE mode an output 4096 KHz clock phase -locked to the line data signal.

LTx(Pin No 26) : Transmit Line Signal Output is a high impedance current source output designed to drive a nominal 50 ohm line through a 2:1 ratio transformer. A 20 ohm resistor is to be connected in series between this pin and the transformer.

V_{bias} (Pin No 27) Bias Voltage : analog ground for Tx and Rx transformers. This pin must be decoupled to V_{DD} through a 10 micro farad capacitor with good high frequency characteristics.

LRx(Pin No 25) : Receive Line Signal Input for pseudo-ternary line signal to be connected to the line through a 2:1 transformer. A $5\ k\Omega$ resistor should be added in series between this pin and the transformer when TE mode is selected. A DC bias level on this input equal to V_{bias} must be maintained.

ISDN NT1 Function : The SNIC can be combined with the MT8972 (DNIC) Digital Network Interface Circuit to implement an ISDN NT1 function as shown in *Figure 4.4* :

In addition to the pins defined earlier, following pins of MT8930 are used in ISDN NT1 function :

P/$\overline{\text{SC}}$(Pin No 11) is Parallel/Serial Control Input (Cmode=0) determines if the serial C-channel or microport pins are the source of chip control when controllerless mode is selected. If the ST-BUS is chosen as the source, the dedicated Control input pins are ignored but the status output pins remain valid.

NT/$\overline{\text{TE}}$(Pin No 8) Network termination/Terminal equipment : S-BUS operational mode select input. The device is configured in a Network Termination (NT) mode, when high, or in a Terminal Equipment mode when low.

RSTi (Pin No 23): Reset Input If '0', sets all control registers to the default conditions, resets activate state machines to the deactivated state, resets HDLC.

STAR (Pin No 24): 192 kbit/s receive data output fixed relative to the ST-BUS time base. A group of NTs can be wired together to create a star configuration.

Cmode (Pin No 7) : Controller Mode Select Input : when high, microprocessor control is selected. When low the controllerless mode is enabled and the microport pins are redefined as control inputs and status outputs.

S-Bus Interface

The S-bus is a four wire, full duplex time division multiplexed transmission facility which exchanges information at 192 Kbits/sec rate including two 64 Kbits/sec PCM voice or data channels, a 16 Kbits/sec signalling channel and 48 Kbits/sec for synchronization and overhead.

The B1 and B2 channels each have a bandwidth of 64 Kbits/sec and are used to carry PCM voice or data across the network. The D-channel is primarily intended to carry signalling information for circuit switching through the ISDN network. Access to the depacketized D-channel is only granted through the parallel micro processor port.

The C channel provides a means for the system to control and monitor the functionality of the SNIC. The C-channel provides access to two registers which provide complete control over the state activation machine, the D-channel priority mechanism as well as the various maintenance functions. The line code used on the S-interface is a Pseudo ternary code.

State Activation

The protocol used by state activation controller is defined as follows :

1. In the deactivated state, neither the NT nor TE assert a signal on the line (Info0).
2. If the TE wants to initiate activation, it must begin transmitting a continuous signal consisting of a positive zero, a negative zero followed by six ones.
3. Once the NT has detected Info1, it begins to transmit Info2 which consists of an S-Bus frame with zeros in the B and D channel and the activation bit (A) set to zero.
4. As soon as the TE synchronises to Info2, it responds with a valid S-Bus frame with data in the B1, B2 and D-channel(Inf03).
5. The NT will then transmit a valid frame with data in the B1, B2 and D-channel. It will also set the activation bit (A) to binary one once synchronization to Info3 is achieved.

If the NT wishes to initiate the activation, the first two steps are ignored and the NT starts sending Info2. To initiate a deactivation, either end begins to send Info0 (Idle line).

D-Channel Priority Mechanism

The SNIC contains a hardware priority mechanism for D-channel contention resolution. All the TEs connected in a point-to-multipoint configuration are allocated the D-channel using a symmetric approach. Allocation of the D-channel is accomplished by monitoring the D-echo channel (E-bit) and incrementing the D-channel priority counter with every consecutive one echoed back in the E bit. Any zero found on the D-echo channel will reset the priority counter.

There are two classes of priority within the SNIC, one user accessible and the other being strictly internal. The user accessible priority selects the class of operation and has precedence over the internal priority. The internal priority will select the level of priority within each class. User accessible priority selects the terminal count as 8/9 or 10/11 consecutive ones on the E-bit. The internal priority selects the terminal between 8 or 9 for high class and 10 or 11 for low class. The first terminal equipment to attain the E-bit priority count will immediately take control of the D-channel by sending the opening flag. If more than one terminal has the same priority, all but one of them will eventually detect a collision. The TEs that detect collision will immediately stop transmitting on the D channel, generate an interrupt through the Dcoll bit, reset the DCack bit on the next frame pulse, and restart the counting process. The remainder of the packet in the Tx FIFO is ignored.

After successfully completing a transmission, the internal priority level is reduced from high to low. The internal priority will only be increased once the terminal count for the respective level of priority has been achieved, if TE has high priority internally and externally, it must count 8 consecutive ones in the D-echo channel. Once this is achieved and successful transmission has been completed, the internal priority is reduced to a lower level i.e count=9. This terminal will not return to the high internal priority until 9 consecutive ones have been monitored on the D-echo channel.

Line Wiring Configuration:

The following three wiring configurations can be interfaced to MT8930.

1. Point-to-Point Configuration.
2. Short-Passive Bus Configuration.

3. Extended Passive Bus Configuration.
The selection of the wiring configurations is performed using the timing bit (B4 of NT mode Control Register).

For the short passive bus , the TE devices are connected at random points along the cable. For the extended passive bus all connection points are grouped at the far end of the cable from the NT.

For an NT SNIC in fixed timing mode, the VCO and Rx filters/peak detectors are disabled and the threshold voltage is fixed. However, for a TE SNIC or an NT SNIC in adaptive timing mode, the VCO and Rx filters/peak detectors are enabled. In this manner, the device can compensate for variable round trip delays and line attenuation using a threshold voltage set to a fixed percentage of the pulse peak amplitude.

On power-up or after a reset, the SNIC is set to operate in fixed timing mode. To switch to adaptive timing, the user should:

1. Set the DR bit to 1
2. Set the timing bit to 1
3. wait for 100 ms period.
4. Proceed in using the AR and DR bits as desired.

Switching from adaptive timing mode is completed by resetting the Timing bit.

ST-BUS Interface

The ST-BUS is a synchronous time division multiplexed serial bussing scheme with data streams operating at 2048 kbit/s configured as 32, 64 kbit/s channels. Synchronization of the data transfer is provided from a frame pulse which identifies the frame boundaries and repeats at an 8 KHz rate. All timing signals (i.e $\overline{F0b}\&\overline{C4b}$ are identified as bidirectional (denoted by the terminating b). The I/O configuration of these pins is controlled by the mode of operation (NT or TE). In the NT mode, all the synchronized signals are supplied from an external source and the SNIC uses this timing while transferring information to and from the S or ST-BUS. In the TE mode, timing is generated from an on board analog phase locked loop which extracts timing from the received data on the S-Bus and generates the system the system 4096 KHz ($\overline{C4b}$)

and frame pulse ($\overline{F0b}$). By implementing the voltage control oscillator (VCO) on the chip, the system timing signals are produced without the need of an external oscillator/crystal.

The SNIC uses the first four channels on the ST-BUS. To simplify the distribution of the serial stream, the SNIC provides a delayed frame pulse ($\overline{F0od}$) to eliminate the need for a channel assignment circuit. This signal is used to drive subsequent devices in the daisy chain. In this type of arrangement, only the first SNIC in the chain will receive the system frame pulse ($\overline{F0b}$) with the following devices receiving its predecessor's delayed output frame pulse ($\overline{F0od}$).

The SNIC makes efficient use of its TDM bus through the star configuration. It does so by sharing four common ST-BUS channels to multiple NT devices. Up to eight SNICs in NT mode with physically independent S-Buses can be connected in parallel to realise a star configuration as shown in *figure 4.10* All connected into the star will carry the same input, thus information is sent to all TEs simultaneously. The 2B+D data received from every TE is transmitted to all NTs through the star pin. Consequently all the DSTo streams will carry identical 2B+D data reflecting what is being transmitted by the various TEs.

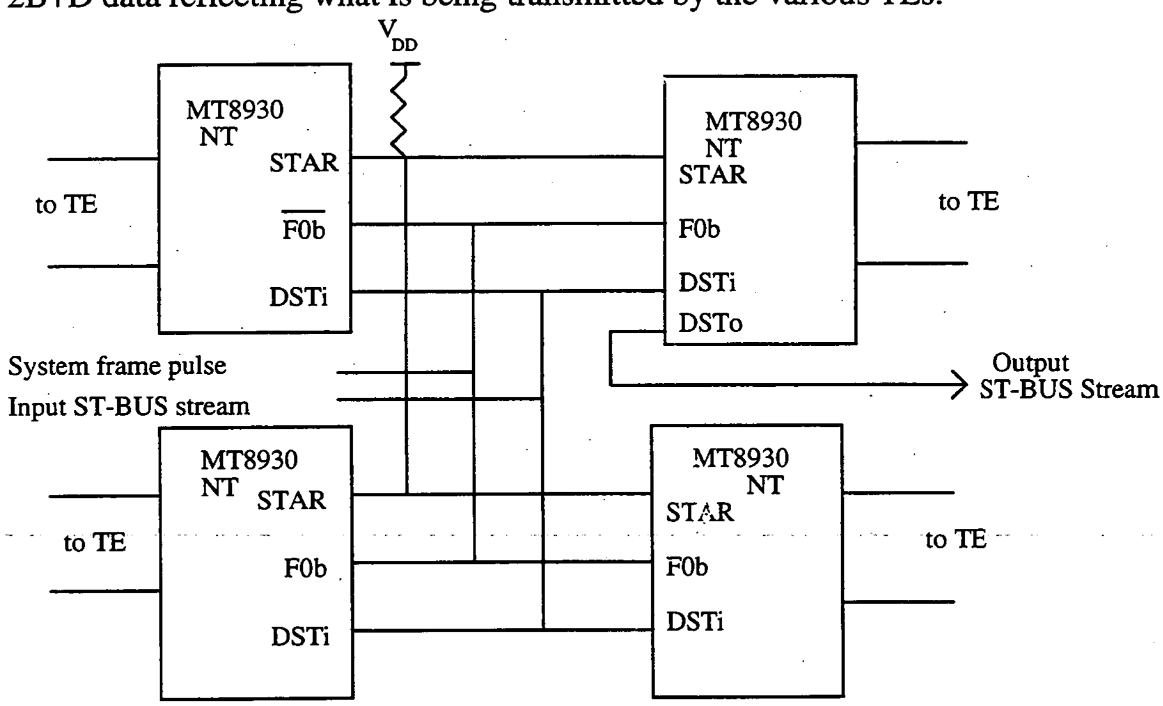


Figure 4.11

Microprocessor/Control Interface

The parallel port on the SNIC operates as either a general purpose microprocessor interface or as a hardwired control port. In microprocessor control mode (Cmode = 1), the parallel port is compatible with either Motorola or Intel multiplexed bus signals and timing. The parallel port on the SNIC allows complete control of the HDLC transceiver and access to all the data, control and status registers. The internal registers can be accessed through the microprocessor port only when the Cmode pin is held high. When the Cmode pin is low, controllerless mode is selected and the parallel port reverts to hardwired control/status pins. This allows the MT8930 to function without the need for a controlling microprocessor. In the controllerless mode, the parallel bus has direct connection to the relevant control/status registers.

The data in TE or NT mode status register, depending upon the mode selected, is always sent out on the C-channel of the DSTo. However, in microprocessor control mode the user can overwrite this data by writing to the DSTo C-channel Register. This access can be done anytime outside the frame pulse interval of the ST-Bus frame. The data written in the current ST-BUS frame will only appear in the C-channel of the following frame.

The least significant bit (B0) of the C-channel Register, selects between the control register or the diagnostic register. Setting the B0 of the C-channel Register to '0' allow access to the control register. Setting the LSB of the C-channel Register to '1' allow access to the diagnostic register

4.7.3 Digital Network Interface Circuit *(MT8972 chip)*

U - Interface Requirements :

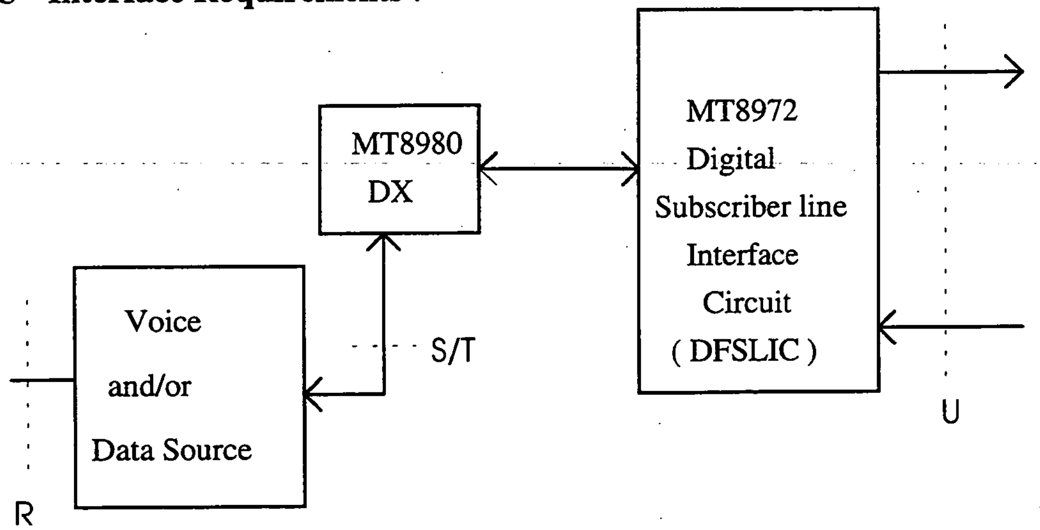


Figure 4.12

Brief detail about the chip MT8972 *(DNIC)*
1. 22 pin DIP, 28 pin PLCC
2. Simplified cancelling
3. Low power
4. Two wire echo cancelling which enables use of existing cable plant
5. Multiple loopbacks
6. Fast convergence.

Following pins are used in this configuration..
DSTi(Pin No 13) : Data ST-BUS In is serial PCM/data output in DN mode. In MOD mode this is a continuous bit stream at the bit rate selected.
DSTo(Pin No 12) : Data ST-BUS Out is serial PCM/data input in DN mode. In MOD mode this is a continuous bit stream at the bit rate selected.
MS2-MS0 (Pin No 4-6) : Mode Select inputs. The logic level present on these pins select the various operating modes for a particular application.
V_{bias} (Pin No 2) : Internal Bias Voltage output. Connected via 0.33ΩF decoupling capacitor to V_{DD}
V_{ref}(Pin No 3) : Internal Reference Voltage output. Connected via 0.33Ω F decoupling capacitor to V_{DD}.
OSC2 (Pin No 16) : Oscillator Output. CMOS Output
OSC1 (Pin No 17) : Oscillator Input. CMOS Input.

The MT8972 (DNIC) is a multifunction device capable of providing high speed, full duplex digital transmission up to 160 kbit/s over a twisted wire pair. It uses adaptive echo cancellation techniques and transfer data in (2B+D) format compatible to the ISDN basic rate. Primarily MT8972 is used as an interface for the Integrated Services Digital Network (ISDN).

In the ISDN, the DNIC is ideal for providing the interface at the U-reference point. The device supports the 2B+D channel format, two 64 kbit/s B-channels and one 16 kbit/s D-channel, over two wires as recommended by CCITT. The line data is converted to and from the ST-BUS form on the system side of the network to allow for easy interfacing with other components such as the S-interface device in an NT1 arrangement.

Within the terminal equipment the MT8972 would terminate the line and encode/decode the data and voice for transmission while additional electronics could provide interfaces for a standard telephone set and any number of data ports supporting standard data rates for such things as computer communications and telemetry for ***credit card verification.***

The DNIC provides a bidirectional interface between the DV (data/voice) port and a full duplex line operating at 80 or 160 kbit/s over a single pair of twisted wires. The DNIC has three serial ports. The DV port (DSTi/Di, DSTo/Do), the CD (control/data) port (CDSTi/CDi, CDSTo/CDo) and a line port (L_{IN}, L_{OUT}). The data on the line is made up of information from the DV and CD ports. The DNIC must combine information received from both the DV and CD ports and put it onto the line. At the same time, the data received from the line must be split into the various channels and directed to the proper ports. The usable data rates are 72 and 144 kbit/s as required for the basic rate interface in ISDN. Full duplex transmission is made possible through on board adaptive echo cancellation.

The DNIC has various modes of operation which are selected through the mode select pins MSO-2. The two major modes of operation are the Modem (MOD) and Digital Network (DN) modes. MOD mode is a transparent 80 or 160 kbit/s modem. In DN mode the line carries the B and D channels formatted for the ISDN at either 80 or 160 kbit/s. In DN mode the DV and CD ports are standard ST-BUS and in MOD mode they are transparent serial data streams at 80 or 160 kbit/s.

In Digital Network (DN) mode there are three channels transferred by the DV and CD ports. They are the B, C and D channels. The B1 and B2 channels each have a bandwidth of 64 kbit/s and are used for carrying PCM encoded voice or data. These channels are always transmitted and received through the DV port. The C-channel having a bandwidth of 64 kbit/s, provides a means for the system to control the DNIC and for the DNIC to pass status information back to the system. The C-channel has a Housekeeping (HK) bit which is the only bit of the C-channel transmitted and received on the line. The D-channel can be transmitted or received on the line with either a 8,16 or 64 kbit/s bandwidth depending on the Din's mode of operation. Both the HK bit and the D-channel can be used for end-to-end signalling or ***low speed data transfer.*** In dual port mode the C and D channels are accessed via the CD port while in the single port mode they are transferred through the DV port along with the B1 and B2 channels.

In Digital Network (DN) mode, upon entering the DNIC from the DV and CD ports, the B-channel data, D-channel D_0, the HK bit of the C-channel and a SYNC bit are combined in a serial format to be sent out on the line by the Transmit Interface.

For any two DNICs on a link, one must be in a SLV mode with the other in MAS mode. The scrambled data is differentially encoded which serves to make the data on the line polarity independent. It is then biphase encoded. before leaving the DNIC the differentially encoded biphase data is passed through a pulse shaping bandpass transmit filter that filters out the high and low frequency components and conditions the signal for transmission on the line.

As shown in MITEL Signalling solution figure , functions of second layer, software and hardware involved in this paper are discussed below.

4.8 Layer 2 - Data Link Layer

Functions of Data link layer

1. Procedures to transfer messages between D-channel and Layer 3.
2. Synchronisation and error control function
3. Frame formatting
4. Link addressing
5. Error checking
6. Sequencing

High Level Data Link Control (HDLC) Requirements

1. Bit oriented frame structure
2. Resides in layer 2 of OSI model.
3. Data transparency by zero bit insertion
4. Error checking with ARQ.
5. Address recognition

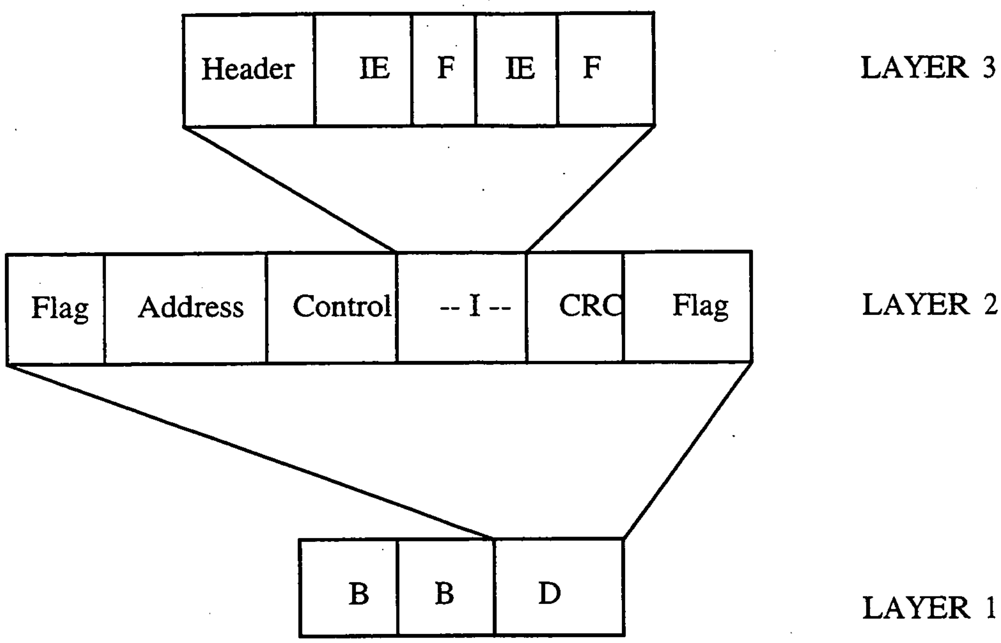


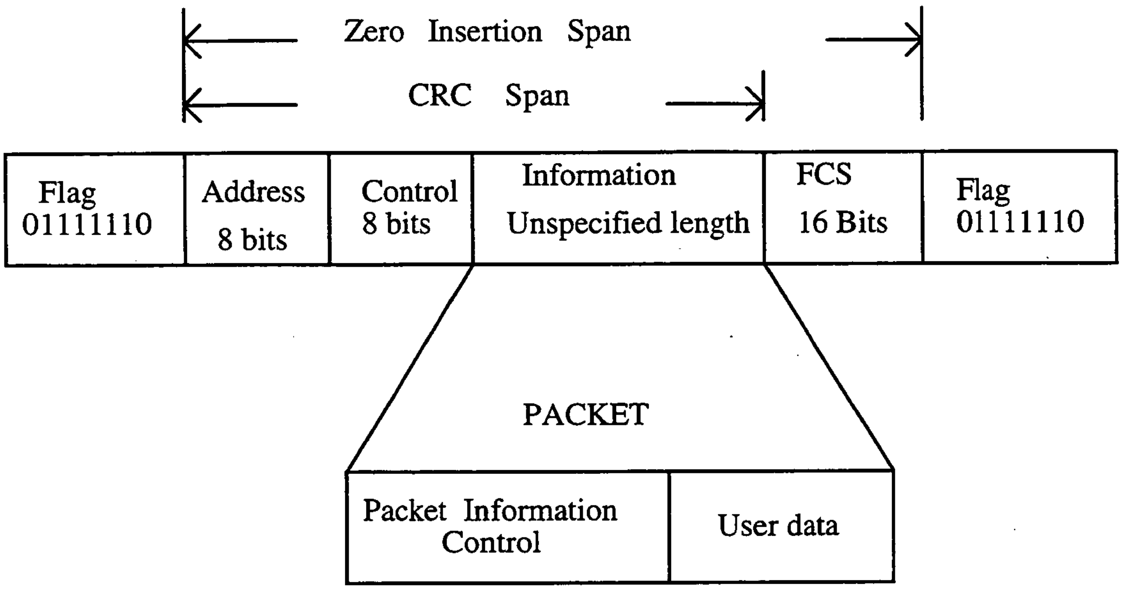
Figure4.13 Basic frame structure at network, data-link and physical layers.

HDLC Transceiver

The HDLC Transceiver handles the bit oriented protocol structure and formats the D-channel as per level 2 of the X.25 packet switching protocol defined by CCITT. It transmits and receives the packetized data, information or control, serially in a format shown below, while providing data transparency by zero insertion and deletion. It generates and detects the flags, various link channel states and the abort sequence. Further it provides a cyclic redundancy check on the data packets using the CCITT defined polynomial. Other features provided by the HDLC include, independent port selection for transmit and received data (eg transmit on S-Bus and receive from ST-BUS), selectable 16 or 64 kbits/s D channel as well as an HDLC loopback from the transmit to the receive port. These features are enabled through the HDLC control registers.

HDLC Frame Format

All frames start with an opening flag and end with a closing flag as shown below. Between these two flags, a frame contains the data and the frame check sequence.



* Packet information is generated by Layer 3 and higher.

Figure 4.14 HDLC Frame Structure

1. The flag is a unique pattern of 8 bits (01111110) defining the frame boundary. The transmit section generates the flags and appends them automatically to the frame to be transmitted. The receive section searches the incoming packets for flags on a bit-by-bit basis and establishes frame synchronization. The flags are used only to identify and synchronize the received frame and are not transferred to the FIFO.

2. The data field refers to the Address, Control and information fields defined in the CCITT recomendations. A valid frame should have a data field of at least 16 bits. The first and second byte in the data field is the address of the frame.

3. The 16 bits following the data field are the frame check sequence bits. The generator polynomial is G(x) $= x^{16} + x^{12} + x^{5} + 1$. The transmitter calculates the FCS on all bits of the data field and transmits the complement of the FCS with most significant bit first. The receiver performs a similar computation on all bits of the received data but also includes the FCS field. The generating polynomial will assure that if the integrity of the transmitted data was maintained, the remainder

will have a consistent pattern and this can be used to identify, with high probability, any bit errors occurred during transmission. The error status of the received packet is indicated by B7 and B6 bits in the HDLC Status Register.

4. The transmitter while sending either data from the FIFO or the 16 bits FCS, checks the transmission on a bit by bit basis and inserts a ZERO after every sequence of five continuous one's (including the last five bits of FCS) to ensure that the flag sequence is not imitated. Similarly the receiver examines the incoming frame content and discards any zero directly following the five continuous ones.

5. The transmitter aborts a frame by sending a zero followed by seven consecutive one's. On the receive side, a frame abort is defined as seven or more continuous one's occurring after the start flag and before the end flag of a packet. An interrupt can be generated on reception of the abort sequence using FA bit in the HDLC Interrupt Mask/Vector Registers.

When the HDLC Transceiver is not sending packets, the transmitter can be in one of the two states mentioned below depending on the status of the IFTF bit in the HDLC Control Register.
1. Idle state is defined as 15 or more continuous ONEs. When the HDLC Protocoller is observing this condition on the receiving channel, the idle bit on the HDLC status register is set HIGH. On the transmit side , the protocoller ends the transmission of all ones(idle state) when data is loaded into the transmit FIFO.

CCITT I.430 specification requires every TE that does not have layer 2 frames to transmit, to send binary ONEs on the D-channel. In this manner ,other TEs on the line will have the opportunity to access the D-channel using the priority mechanism circuitry.

2. The HDLC protocoller transmits continuous flags ($7E_{Hex}$) in interframe time state and ends this state when data is loaded into the transmit FIFO. The reception of the interframe time fill will have the effect of setting the idle bit in the HDLC status register to '0'.

HDLC Transmitter

On power up, the HDLC transmitter is disabled and is in the idle state. The transmitter is enabled by setting the TxEN bit in the HDLC Control Register 1. To start a packet ,the data is written into the 19 byte Transmit FIFO starting with the address field. All the data will be written to the FIFO in a byte wide manner. When the data is detected in the transmit FIFO, the HDLC protocoller will proceed in one of the following ways :

1. If the transmitter is in idle state, the present byte of ones is completely transmitted before sending the opening flag. The data in the transmit FIFO is then transmitted. A TE transmitting on the D-channel will use contention circuitry.
2. If the transmitter is in the interframe time fill state, the flag presently being transmitted is used as the opening flag for the packet stored in the transmit FIFO.
3. If the HDLC transmitter is in transparent data mode3, the protocol functions are disabled and the data in the transmit FIFO is transmitted without a framing structure.

MS6060 LAP-D/MS6070 CALL CONTROL

1. Implementation of CCITT recommendation Q.921/Q.931
    * Automatic TEI assignment
    * Multiple logical links
    * Functional signalling

Features of MS6060/MS6070

1. LAP-D software is a full implementation of the data link entity as defined by CCITT Q.921
2. Highly modular and transportable software written in C programming language .

It is fast, easy integration of proven LAP-D Data Link Entity software into existing ISDN systems. It is used for rapid prototyping of ISDN application software. Q.921 LAP-D protocol monitoring is included in it. It has the facility for ISDN protocol conversion. This software makes the implementation of ISDN applications with D-channel processing requirements quick and easy. In addition to CCITT Q.921, it has following supporting features :

1. Use of the P/F bit.
2. Unacknowledged information transfer.
3. Manual and Automatic TEI assignment
4. Multiple frame operation.
5. Exception condition reporting and recovery
6. Data link layer monitor function.

7. Deactivation procedures

Digital Switch ***(MT8980)***

This device is basically designed for modern digital exchange, PBX or Central Office requirements. It might not be of much use in the domestic environment.

It provides simultaneous connections for up to 256, 64 kbits/s channels. Each of the eight serial inputs and outputs consist of 32, 64 kbits/s channels multiplexed to form a 2048 kbit/s ST-BUS stream.

Chapter5

D CHANNEL DELAY ANALYSIS AND SIMULATION

5.1 Description of the D-channel Access Protocol.

The following procedure allows for a number of terminals connected in a multipoint configuration to gain access to the D channel in an orderly fashion. The procedure ensures that ,even in case where two or more terminals attempt to access the D channel simultaneously, one terminal will always be successful in completing the transmission of its information. This procedure relies upon the use of layer 2 frames delimited by flags consisting of the binary pattern 01111110 and the use of zero bit insertion to prevent flag imitation .This procedure also permits terminals to operate in a point-to-point manner. Bit convention is according to the Pseudo-ternary - code as explained section 2.6 . The absence of a signal on the line represents a bit value of one.

The D channel is a synchronous channel. Multiple terminals can be connected to one D channel. A terminal sends(tristated) binary 1's on the D-channel when it has no layer-2 frames to transmit. The bit value of the logical AND of the latest transmitted bits from all terminals connected to the D-channel is recognised at the receiving end, and the bit value is echoed back by NT unit to all terminals through the D- echo channel. Therefore the consecutive 1' s are echoed back , while the channel is idle.

While in active condition (ie., power "on" condition), a terminal monitors the D-echo channel to count the number of consecutive 1's . If a binary zero is detected , the terminal resets the counter and starts again. The value of the counter can not be increased over 11. It is important to note that a terminal goes on counting number of 1's even when it has no message to transmit. A terminal having frame of layer 2 to send can begin to transmit them on the D channel when the counter reaches required value.

While transmitting messages. on the D-channel, a terminal goes on monitoring the D-echo channel and compares the last transmitted bit with the next available D-echo bit. If the two bits are identical , it continues to transmit the frame until completion. But , if not, it ceases transmitting the frame immediately and return to the D-channel monitoring state. Therefore , one of the competing terminals will always transmit successfully.

A terminal is permitted on the D-channel by detecting consecutive 1's on the D-echo channel. The required length of a sequence is determined by the type of the frame to be transmitted. The signalling message is given high priority , and packet and telemetry messages are given low priority. The high priority class message is transmitted on a non-preemptive mode over the low-priority class. Furthermore , each priority class is again divided into two levels.

Each terminal has the counter C which counts the number of consecutive 1's . A terminal can start frame transmission when C equals or exceeds the value '$x1$' for signalling message and the value '$x2$' for packet and telemetry message. The value of '$x1$' is set to 8 for the normal level and 9 for the lower level. The value of 'x2' is set to 10 for the normal level and 11 for the lower level.

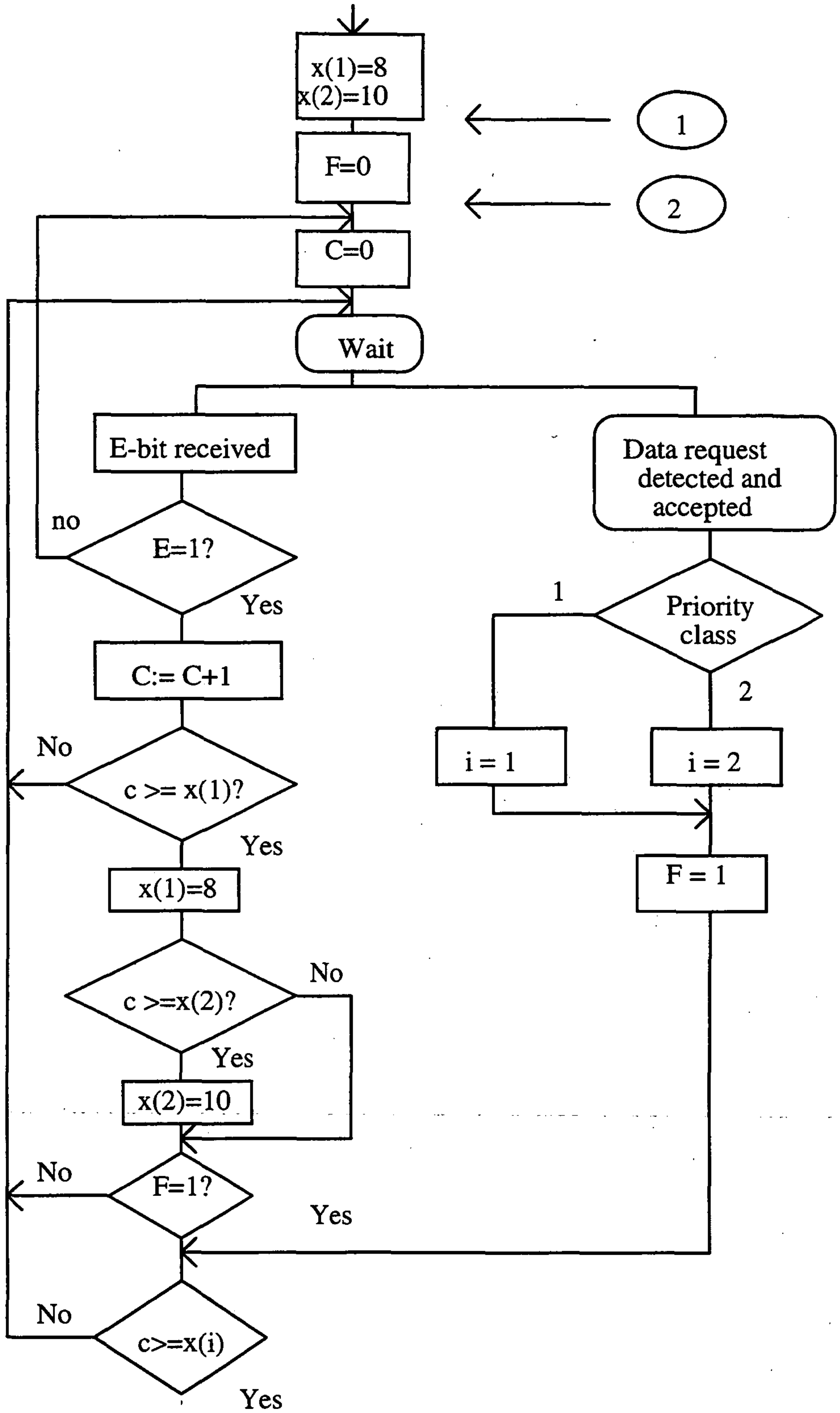
For a priority class, normal -level priority is changed into lower-level priority when a terminal has successfully transmitted a frame of that priority class on the D-channel. The lower level priority in a priority class returns back to the normal-level priority when the counter C has reached the value of the lower level of that priority class . Figure 5.1 shows the Specification and Description Language(SDL) diagram (CCITT I.430).

On the whole, the D-channel access includes the fairness of a polling system and adopts the collision detection scheme of CSMA/CD(Carrier Sense Multiple Access with collision Detection).But neither model can be applied to the analysis of the D-channel access protocol. One of the approach is analyse the system as a FIFO queue with non preemptive priority scheme

There are three possible types of packets transmitted namely signalling , data and telemetry. Signalling traffic has higher priority over the other two. To simplify the simulation task , the following assumptions are made.
D channel access algorithm is approximated by nonpreemptive priority system with two different traffic types..

- D channel capacity is 16 kbps.
- Only signalling and teletraffic packets are considered. Data packets are not considered separately because the behaviour of teletraffic and other data packets are determined only by the parameters for that traffic.
- All the signalling packets which are generated from different station are either transmitted immediately or placed in a FIFO buffer.(Queue1).
- All the teletraffic packets generated from different station are transmitted immediately or placed in a FIFO buffer (Queue2).
- Signalling packets have non preemptive priority over other packets

Fig 4.1 FLOWCHART FOR D-CHANNEL ACCESS CONTROL



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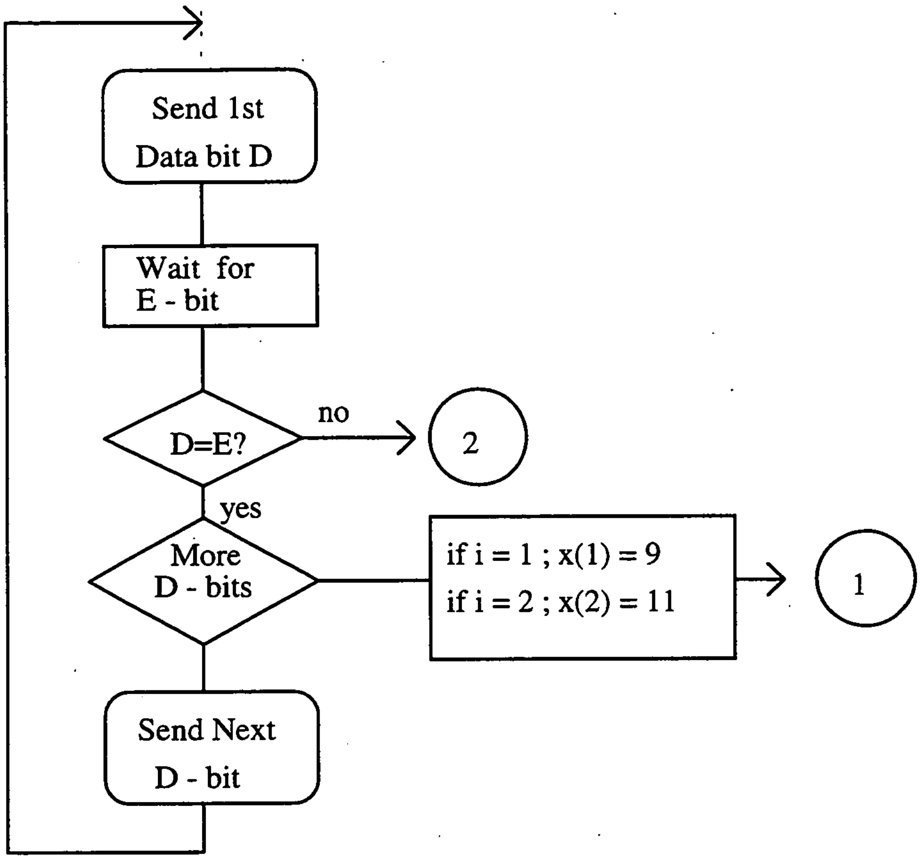


- For signalling and data packets , a layer 2 frame consist of an information field and additional 7 octets (56 bits) the use of layer 2 header and trailer.
- Each station generates signalling and packet messages independently, according to the Poisson distribution process.(Random arrivals).
- The number of stations is a variable
- The elementary time unit is bit .
- The mean length of the packet information field is 128 octets(1024 bits) .
- The length of the signalling information field is 9 octets (72 bits) . Simulation is carried for both constant length (9 octets) and exponential distributed length.
- Since the traffic of signalling message is low , the signalling utilisation ρs is considered only up to 0.4.
- All the signalling queue messages have same service time and all the teletraffic messages have the same service time.

Flow Chart for simulation model.

- In the case of type 1 arrival if the server is idle at the time of arrival , a departure is scheduled immediately. Otherwise , the packet is put into a high priority queue (Queue1). Similarly in the case of type2 arrival if the server is idle , the packet is served immediately . Otherwise it is put into the low priority queue (Queue2).

Arrival of type 1

Arrival of type 2

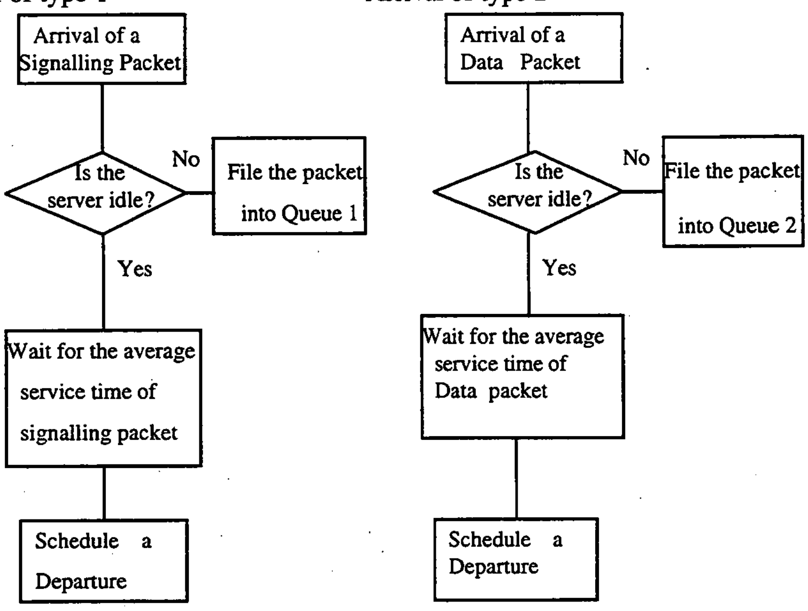


Figure 5.2

- Departure is the process representing the service routine. Here two types of services take place: Service of Signalling packet and service of Data packet.

Two types of signalling packets are investigated here . In first case signalling packets are assumed to be of random length with mean value of the packet length of 9 bytes. In the second case signalling packets are assumed to be of constant length of 9 bytes. Hence service time for signalling packet is either constant 0.0045 bit. or a random variable with mean value of 0.0045 bit .(Data rate on ISDN D channel is 16000 bits/sec). Mean packet length for Data packet is assumed to be 128 bytes including the overhead. This leads to 0.064 bit mean service time . Service time is assumed to be exponentially distributed.

Following flowchart shows how the Departure event is working.

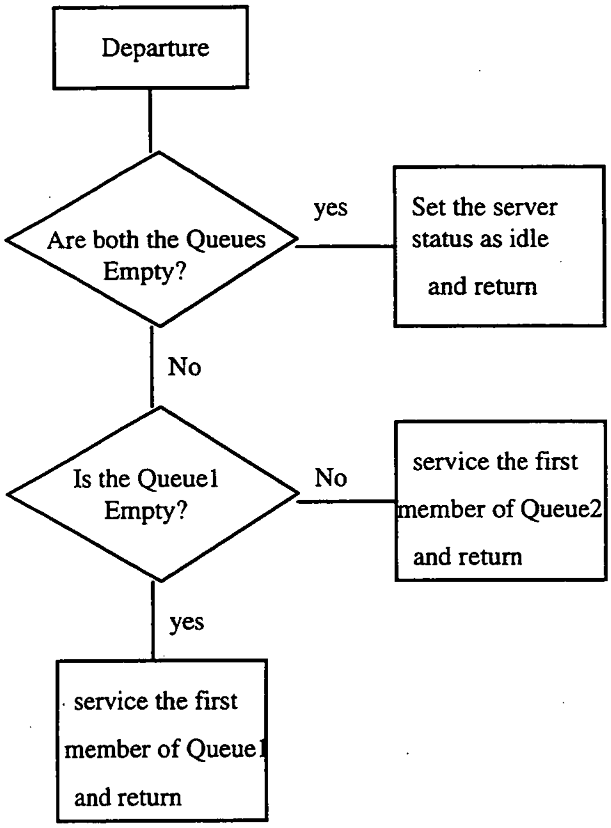
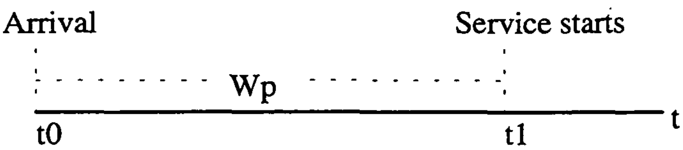


Figure 5.3

5.2 Analytical model of non preemptive queuing system.

In general say there are 'r' classes of customers , to be served at a queue . Their respective arrival rates are $\lambda 1$, λ 2, λ 3...λ r respectively , each representing a Poisson stream . The average service time is $1/\mu k$ for the kth class. k=1,2,3..r.

The highest priority class is known to be 1 , the lowest r, in descending order as labelled. Now we can calculate the average waiting time for any class, assuming non-preemptive service . Consider class P (1<=P<=r) in particular .Let a typical customer of this class arrive at an arbitrary time t0. Its random waiting time *Wp* is measured from three sources. It must wait a random amount of time T0 until customer currently in service completes service. It must wait a random number *Tk* units of time until customers of priority k lower than or equal to 'P' already enqueued at the arrival time to complete service. Finally ,it must wait a random time *Tk* to service customers of each class k of priority lower than p arriving during the waiting time *Wp*.



Putting the observations together, we write

$$Wp = T0 + \sum_{k=1}^{p} Tk + \sum_{k=1}^{p-1} Tk' \quad \text{------------------- } 1$$

Taking expectations term by term , the average waiting time E(Wp) of priority p is given by

$$E(Wp) = E(T0) + \sum_{k=1}^{p} E(Tk) + \sum_{k=1}^{p-1} E(Tk') \quad \text{------------------- } 2$$

To find each of the three average times i n eq(2) note first that E(Tk) is due to an average number E(mk) customers of category k waiting in the system , each requiring 1/μk units of service on the average .Then we have

$$E(Tk) = E(mk)/\mu k \quad \text{-------------------------------------- } 3$$

From Little's formula we have E(mk) related to the average wait time E(wk), specifically

$$E(mk) = \lambda k E(Wk) \quad \text{--}4$$

Combining 3 and 4

$$E(Tk) = \rho k E(Wk) \quad \text{--}5$$

Now consider the term E(Tk') in eq (2). This is due , on the average ,to E(mk') customers of class k arriving during the interval E(Wp). Since the arrival rate is λk and each customer again requires on the average 1/μk units of service , we immediately have

$$E(Tk') = \lambda k E(Wp)/\mu k = \rho k E(Wp) \quad \text{--------------------------}6$$

Consider the remaining term E($T0$). This is the residual service time of a customer in service. For the work conserving non-preemptive queuing system under discussion here (the server always serves customer if one waiting to be served) this is independent of queue discipline . It must be the same if k customers of all k classes are served with the same priority, in their order of arrival . We can use M/G/1 queuing results here.

$$E(T0) = \lambda E(\tau^2)/2 = \sum_{k=1}^{r} \lambda k E(\tau k^2)/2 \text{ ----------------------7}$$

where $E(\tau k^2)$ is the second moment of service time distribution.

using equations (6) , (5) and (2) and solving for the wait time of each class recursively we can get the required results.

Let us assume that the arrivals of the first or higher priority have mean rate λ1 and that the second or lower priority units have mean rate λ2, such that λ= λ1+ λ2. We also suppose that the first -priority items have the right to be served ahead of the others , but that there is no preemption. Let it further be assumed that service time for both type of customers is exponentially distributed with mean values 1 /μ1 and 1/μ2 respectively.

Let us calculate E(*W1*)

from equation (2) we have

$$E(Wp) = E(T0) + \sum_{k=1}^{p} E(Tk) + \sum_{k=1}^{p-1} E(Tk')$$

form equation (5) and (6)

$$\therefore E(w1) = E(T0) + \sum_{k=1}^{p} \rho k E(wk) + \sum_{k=1}^{p-1} \rho k E(wp)$$

third term in the RHS is zero

$$\therefore E(W1) = E(T0) + \sum_{k=1}^{1} \rho k E(wk)$$

$$\therefore E(W1) = E(T0) + \rho 1 E(W1)$$

$$\therefore E(W1) = E(T0)/(1-\rho 1)$$

Now we can substitute the values of E(*T0*) and ρ1

since we have assumed exponential distribution we have $E(\tau k^2) = 1/\mu k^2$ and ρ1= λ1/μ1

$$\therefore E(T0) = \lambda 1/\mu 1^2 + \lambda 2/\mu 2^2$$

$$\therefore \mathrm{E(W1)} = (\lambda 1/\mu 1^2 + \lambda 2/\mu 2^2)/(1-\lambda 1/\mu 1) \text{ ------------------------------8}$$

similarly we can derive for E(W2) which is given by

$$E(W2) = E(T0) + \sum_{k=1}^{2} \rho k E(wk) + \sum_{k=1}^{p-1} \rho k E(wk)$$

After substituting for different values and simplifying we have
$E(W2) = E(T0)/(1-\rho 1)(1-\rho)$
$\therefore E(W2) = (\lambda 1/\mu 1^2 + \lambda 2/\mu 2^2)/(1-\lambda 1/\mu 1)(1-\lambda 1/\mu 1-\lambda 2/\mu 2)$--------------9

5.3 Simulation of D Channel Delay using Simscript II.5

```
"-----------------------------------------------------------------------------------------
"THIS PROGRAM IS TO SIMULATE THE ACCESS DELAY IN ISDN D
CHANNEL
"THIS PROGRAM IS WRITTEN BY SANJAY HEGDE - M.TECH.
INFORMATION SYSTEM
"-----------------------------------------------------------------------------------------
Preamble
    Event notices include arrival1,arrival2, departure and stop.s
    temporary entities
        every packet has a time.of.arrival
        and may belong to the queue1
        and may belong to the queue2
    the system owns the queue1
    the system owns the queue2
    define arr2,arr1,svc,s,wait1.tim,wait2.tim,a1,a2 as a variab
    define nx1,nx2,npkt,times,status as integer variable
    define idle to mean 0
    define busy to mean 1
    accumulate aniq1 as the average of n.queue1
    accumulate aniq2 as the average of n.queue2
    accumulate xbusy as the average of status
    tally mat as the mean of arr1
    tally mst as the mean of svc
    tally mwt1 as the mean of wait1.tim
    tally mwt2 as the mean of wait2.tim
    define i,n1,n2,n3 as integer variable
    define .seconds to mean minutes
    define xx1,xx2 as double variable
end
```

```
"-------------------------------------------------------------------------------------------------------------------
"SIGNNALING MESSAGE PACKET IS REFERED AS "SIGNAL PACKET"
"TELEMETRY MESSAGES ARE REFERED AS "DATA PACKET"
"AVERAGE LENGTH OF THE SIGNLLING PACKET IS 9 OCTETS(72BITS)
"AVERAGE LENGTH OF THE DATA PACKET IS 128 OCTETS(1024 BITS)
"AVERAGE LENGTH OF THE SIGNLLING PACKET IS 9 OCTETS(72BITS)
"AVERAGE LENGTH OF THE DATA PACKET IS 128 OCTETS(1024 BITS)
"SERVICE RATE IS MAXIMUM 16000 BITS PER SECOND
"THERFORE MEAN SERVICE TIME PER SIGNALLING PACKET IS 0.0045 .SECONDS
"MEAN SERVICE TIME FOR DATA PACKET IS 0.064 .SECONDS
"SO WE HAVE TWO DIFFERENT SERVICE RATES AND TWO DIFFERENT ARRIVAL RA
"ARRIVAL RATES ARE CALCULATED ACCORDING TO REQUIRED UTILISATION(EITHER
"PACKET UTILISATION OR SIGNAL UTILISATION) WHILE KEEPING THE UTILSATION OF
"THE SERVER TO MAXIMUM OF ONE.
"DATA PACKET UTILISATION IS THE RATIO OF DATA PACKET ARRIVAL RATE AN
"DATA PACKET SERVICE RATE.
"SIGNALLING PACKET UTILISATION IS RATIO OF SIGNALLING PACKET ARRIVAL
"AND SIGNALLING PACKET SERVICE RATE .
"SERVER UTILISATION IS SUM OF DATA PACKET UTILISATION AND SIGNALLING
"UTILISATION.
"SIGNALLING PACKET HAVE HIGHER PRIORITY THAN DATA PACKETS.
"PRIORITY SCHEME IS NON PREEMPTIVE.
"-------------------------------------------------------------------------------------------------------------------
main
    let minutes.v=1000000
    let hours.v=10
    print 1 line thus
    TYPE THE VALUE OF MEAN ARIVAL TIME FOR DATA PACKET
    read a2
    print 1 line thus
    TYPE THE VALUE OF MEAN ARIVAL TIME FOR SIGNALLING PACKET
    read a1
    let a1=0.01125
    let arr1=exponential.f(a1,1)
    let arr2=exponential.f(a2,1)
    activate an arrival1 in arr1 minutes
```

```
    activate an arrival2 in arr2 minutes
    schedule a stop.sim in 0.01 hours
    start simulation
End
--------------------------------------------------------------------------------
" 1 minute is equal to 16000 bits.
--------------------------------------------------------------------------------
    event arrival1
    let arr1=exponential.f(a1,1)
    activate an arrival1 in arr1 minutes
    add 1 to npkt
    add 1 to nx1
    if status=busy
        create a packet
        let time.of.arrival(packet)=time.v
        file packet in queue1
        let n1=n1+1
        return
    else
        let n3=n3+1
        let wait1.tim=0.0
        add wait1.tim to xx
        schedule a departure in exponential.f(0.0045,1) minutes
        let status = busy
        return
    end

    event arrival2
    let arr2=exponential.f(a2,1)
    activate an arrival2 in arr2 minutes
    add 1 to npkt
    add 1 to nx2
    if status=busy
  add 1 to nx2
   if status=busy
        create a packet
```

```
        let time.of.arrival(packet)=time.v
        File packet in queue2
        let n2=n2+1
        return
    else
        let n3=n3+1
        let wait2.tim=0.0
        schedule a departure in exponential.f(0.064,1) minutes
        let status = busy
        return
    end
event departure
        if queue1 is empty and queue2 is empty
            let status = idle
            return
        else
            if queue1 is empty
             remove first packet from the queue2
             let wait2.tim=time.v-time.of.arrival(packet)
             add wait2.tim to xx2
             destroy packet
             schedule a departure in exponential.f(0.064,1) minutes
             return
            else
             remove first packet from the queue1
             let wait1.tim=time.v-time.of.arrival(packet)
             add wait1.tim to xx1
             destroy packet
             schedule a departure in exponential.f(0.0045,1) minutes
 destroy packet
             schedule a departure in exponential.f(0.0045,1) minutes
        end
    event stop.sim
    let xx1=xx1/nx1
    let xx2=xx2/nx2
    print 14 lines with
```

```
      a2,
      aniq1,
      aniq2,
      xbusy,
      mat,
      mst,
      mwt1*hours.v*minutes.v,
      mwt2*hours.v*minutes.v,
      npkt,
      n1,
      n3,
      n2,
      xx1*hours.v*minutes.v ,
      and xx2*hours.v*minutes.v thus
      a2= **.***
      average queue1 length  **.***
      average queue2 length  **.***
      utilization of server  *.***
      mean arrival time      **.*** minutes
      mean service time      **.*** minutes
      average waiting time 1  ****.***** minutes
      Average waiting time 2 ****.***** minutes
      total ********
      total packets served1 ******
      n3 *******
      total packets served1 ******
      n3 *******
      total packets served2 ******
      xx1= **.****
      xx2=**.*****
      let xx1=0.0
      let xx2=0.0
      let nx1=0
      let nx2=0
  add 1 to times
   if times=10
```

```
        stop
    else
        schedule a stop.sim in 0.01 hours
return
end
```

5.4 Simulation Results and conclusion

Figure 5.4 to Figure 5.12 show the performance results obtained. Following convention is used in all the plots

- Packet utilisation is with reference to data packet utilisation (teletraffic) , where utilisation $\rho_p = \lambda_p / \mu_p$.
- Signalling utilisation is with reference to signalling packet utilisation , where utilisation $\rho_s = \lambda_s / \mu_s$
- Mean packet delay is with reference to data packets
- Mean signalling delay is with reference to signalling packet delay.
- Unit of time is " bit " (with respect to D channel capacity of 16000 kbps).

Figure 5.4 and 5.5 show the analytical results of non preemptive queuing model .These graphs show the variation of mean delay with respect to variation of utilisation of data packet (ρ_p) . Four set of plots are plotted in each case for different values of signalling packet utilisation (ρ_s = 0.4 , 0.3, 0.2, 0.1). Figure 5.4 is the plot of variation of mean signalling delay with respect to variation of data packet utilisation. Random arrival and random service time distribution is assumed for both data and signalling packets. Figure 5.5 is the plot of variation of mean data packet delay Figure 5.5 is the more interesting case because it refers to teletraffic type data .

Figure 5.6 and 5.7 show the simulation results. These two results assume same parameters as analytical results.

Figure 5.8 and 5.9 show the above results for constant length signalling packets . This is more practical because most of the time signalling packets are the same .

Figure 5.10 to 5.12 show the distribution of delay with respect to number of packets. Worst 5% delay calculation shows that delay in accessing D channel for data packet (teletraffic type) is acceptable for applications like point of sale.

From the initial ideas for an integrated digital network at the end of 1960s through the CCITT consensus in 1972, and the actual start of standardisation work by CCITT in 1978 to the introduction of commercial ISDN at the end of 80s, ISDN has come a long way.

ISDN is commercially available in all the industrialised countries of the world but standardisation work for new applications on ISDN is still under research. " Teleaction Teleservice " is one of these applications where the research is carried owing to the fact that success of these services will have long term economical benefits.

Available standards suggest that ISDN D channel is a suitable medium for these applications . Available standards of *Teleaction Teleservices* are investigated in this thesis. Then a performance analysis of ISDN D channel is carried . The D channel performance shows that the delay experienced by a teleaction type message on ISDN D channel is acceptable for utilisations up to 0.9 . Simulation results show that the worst 5% delay on D channel for utilisation of 0.75 is 3.8 sec while the average delay is less than 1 sec. For utilisation of 0.6 the worst 5% delay is 0.1 sec while for utilisation 0.99 it is 30 sec. In the case of real time traffic utilisation is within 0.9 and hence D channel delay is acceptable.

System design is proposed in section 4.6 using MITEL semiconductor devices. Description of all the system elements is included.

There is a scope for future work in this project. Real time data can be collected from existing system and these parameters can be used in simulation. Also , a cost comparison can be carried between existing system and proposed system.

Figure 5.4 Plot of Mean Signalling delay with respect to variation in data packet utilisation. (analytical)

Packet Utilisation *p* p	*ps=0.4*	*p s=0.3*	*p s=0.2*	*p s=0.1*
0.01	65.072	45.44	30.8	19.37858
0.05	133.344	104	82	64.88969
0.1	211.84	171	140.8	117.2275
0.15	302.944	249	208	177.9575
0.2	389.344	323	273.6	235.5564
0.25	473.984	395	336	291.9901
0.3	560.272	468	400	349.5162
0.35	645.4	528	464	406.314
0.4	730.672	614	528	463.1119
0.45	815.872	688	592	519.9098
0.5	899.968	752	656	575.9795
0.55	965.504	816	704	619.6701
0.6		912	784	694.6724
0.65			848	750.7421
0.7			880	779.8692
0.75			960	854.1434
0.8				895.6495
0.85				966.0643

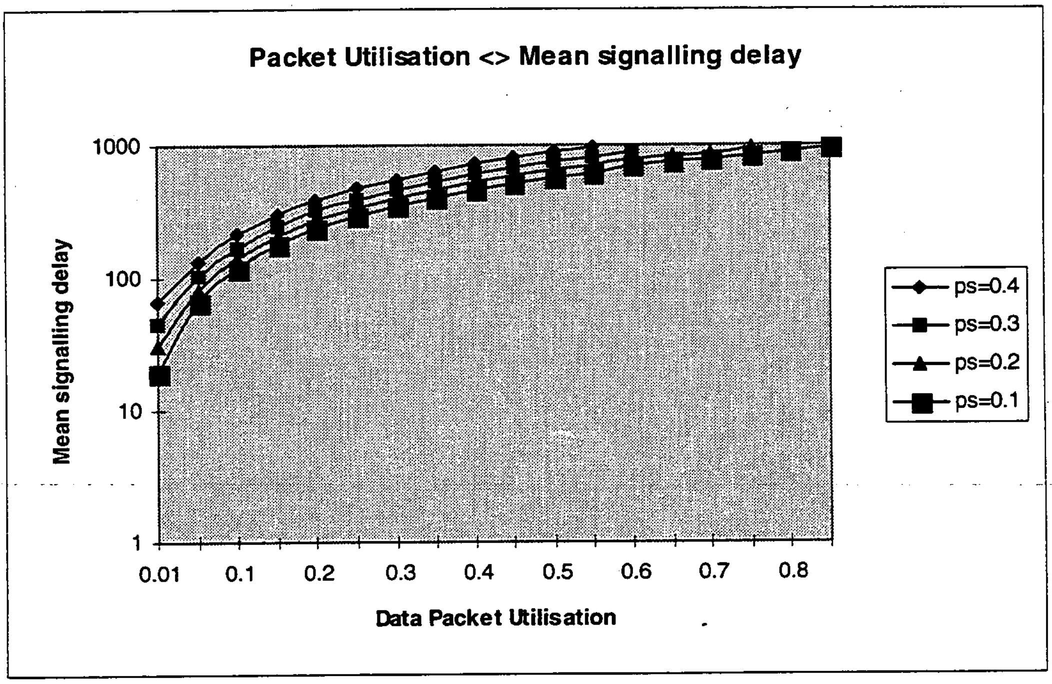


Figure 5.5 Plot of Mean Packet delay with respect to variation in data packet utilisation. (analytical)

Packet Utilisation ρp	ρs=0.4	ρs=0.3	ρs=0.2	ρs=0.1
0.01	110.288	65.84	38.992	21.77368
0.05	242.432	159.8	109.328	76.34081
0.1	420.32	283.3	200.112	145.8053
0.15	672.272	452	321.536	237.0794
0.2	973.344	646	456.672	336.5091
0.25	1352.704	878	613.168	448.9393
0.3	1868.592	1174	804.672	582.6823
0.35	2582.72	1549	1035.2	738.8603
0.4	3653.36	2048	1324.8	926.2238
0.45	5436.224	2736	1696	1155.15
0.5	8928.304	3782	2176	1437.075
0.55	15472.9	5022	2688	1709.907
0.6		9440	4016	2343.067
0.65			5760	3036.983
0.7			7280	3519.266
0.75			17216	5464.07
0.8				7473.711
0.85				16670.08

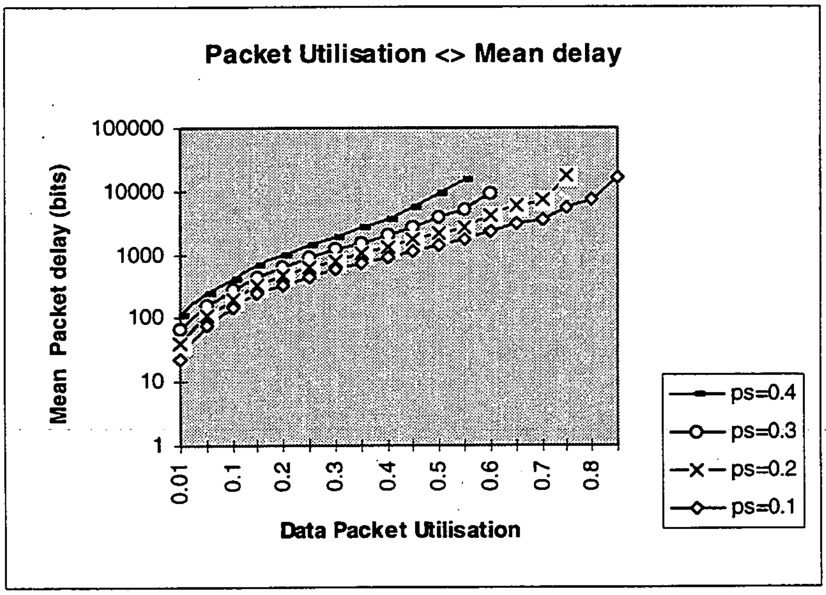


Figure 5.6 Plot of mean signalling delay with respect to variation of data packet utilisation. (simulation)

Packet Utilisation ρp	ρs=0.4	ρs=0.3	ρs=0.2	ρs=0.1
0.01	64	48	30.4	19.2
0.05	136	107.2	78.4	65.6
0.1	217.6	172.8	148.8	124.8
0.15	305.6	257.6	203.2	179.2
0.2	387.2	321.6	267.2	230.4
0.25	473.6	400	340.8	294.4
0.3	556.8	475.2	404.8	352
0.35	632	547.2	473.6	403.2
0.4	720	627.2	534.4	465.6
0.45	808	675.2	592	518.4
0.5	886.4	764.8	651.2	572.8
0.55	971.2	841.6	720	632
0.6		913.6	800	699.2
0.65		976	846.4	752
0.7			889.6	782.4
0.75			953.6	873.6
0.8				896
0.85				950.4

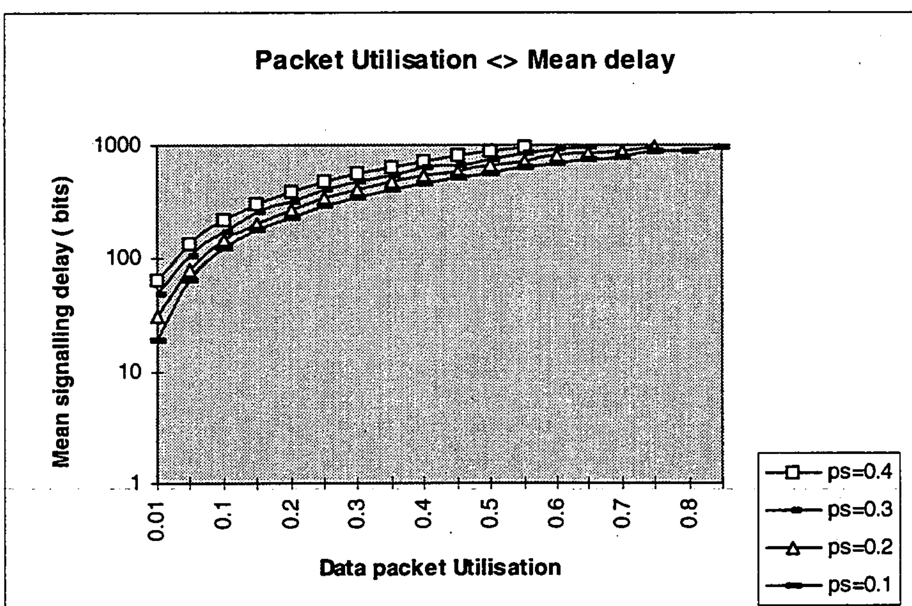


Figure 5.7 Plot of mean packet delay with respect to variation of data packet utilisation. (simulation)

Packet Utilisation ρp	ρs=0.4	ρs=0.3	ρs=0.2	ρs=0.1
0.01	103.2	75.2	33.92	18.56
0.05	227.52	174.88	99.36	66.08
0.1	449.12	279.52	207.84	163.84
0.15	662.72	471.2	304	240.32
0.2	974.08	642.56	448	335.04
0.25	1366.24	879.36	616	450.56
0.3	1824	1216.48	789.44	594.88
0.35	2416	1594.4	1052.8	750.88
0.4	3600	2107.84	1296	926.56
0.45	5264	2685.44	1680	1168
0.5	8427.2	3755.2	2096	1440
0.55	16512	5584	2816	1760
0.6		9873.28	4096	2400
0.65		19152	5520	3024
0.7			7792	3495.84
0.75			16160	5780.8
0.8				7472
0.85				14400

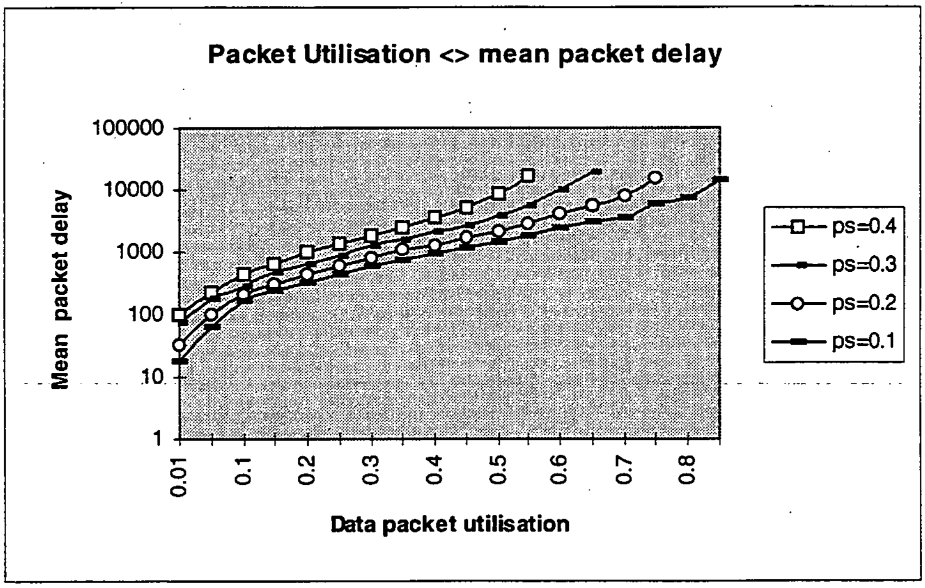


Figure 5.8 Plot of mean signalling delay with respect to variation of data packet utilisation. (simulation - service time for signalling packets is deterministic)

Packet Utilisation ρp	ρs=0.4	ρs=0.3	ρs=0.2
0.01	30.4	26.4	14.4
0.05	86.4	73.6	62.4
0.1	160	136	115.2
0.15	228.8	203.2	168
0.2	307.2	264	236.8
0.25	380.8	328	284.8
0.3	457.6	395.2	344
0.35	526.4	456	404.8
0.4	604.8	524.8	452.8
0.45	676.8	574.4	521.6
0.5	740.8	646.4	571.2
0.55	795.2	704	616
0.6	896	784	688
0.65	966.4	844.8	744
0.7		888	774.4
0.75		948.8	849.6
0.8			891.2
0.85			964.8

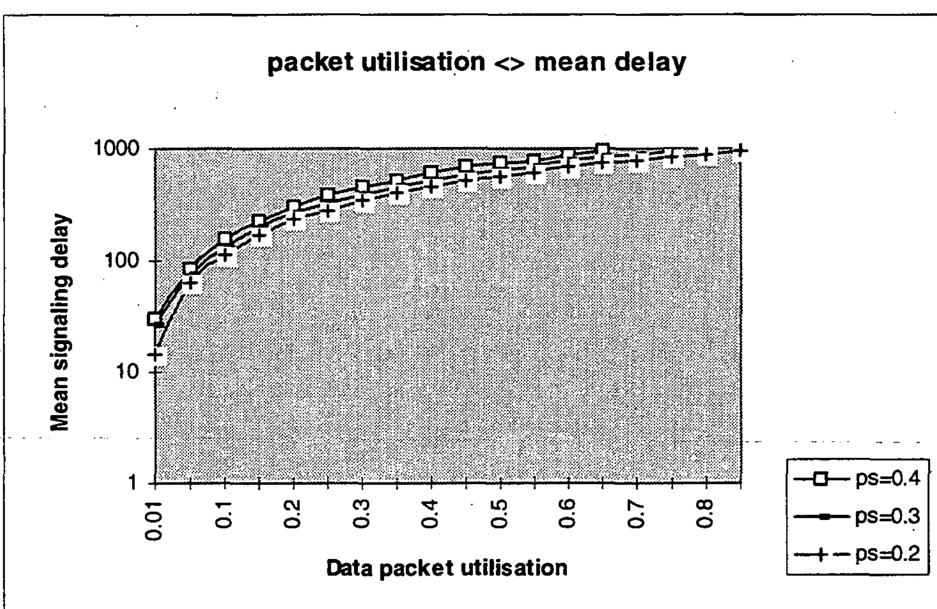


Figure 5.9 Plot of mean packet delay with respect to variation of data packet utilisation. (simulation - service time for signalling packets is deterministic).

Packet Utilisation ρp	ρs=0.4	ρs=0.3	ρs=0.2
0.01	35.2	23.52	15.52
0.05	99	72.3	56
0.1	202.24	170.7	149.44
0.15	258.72	303.68	232
0.2	416.48	443.84	330.56
0.25	618.72	602.4	428.96
0.3	845.92	791.52	572.96
0.35	1161.76	1018.24	725.12
0.4	1497.92	1303.68	903.68
0.45	1976.32	1583.68	1164.32
0.5	2778.08	2154.24	1407.36
0.55	3651.04	2728	1677.92
0.6	5037.92	4025.28	2293.28
0.65	9341.76	5427.2	3046.08
0.7	16434.56	7375.84	3482.56
0.75		15530.88	5371.04
0.8			7391.52
0.85			14957.12

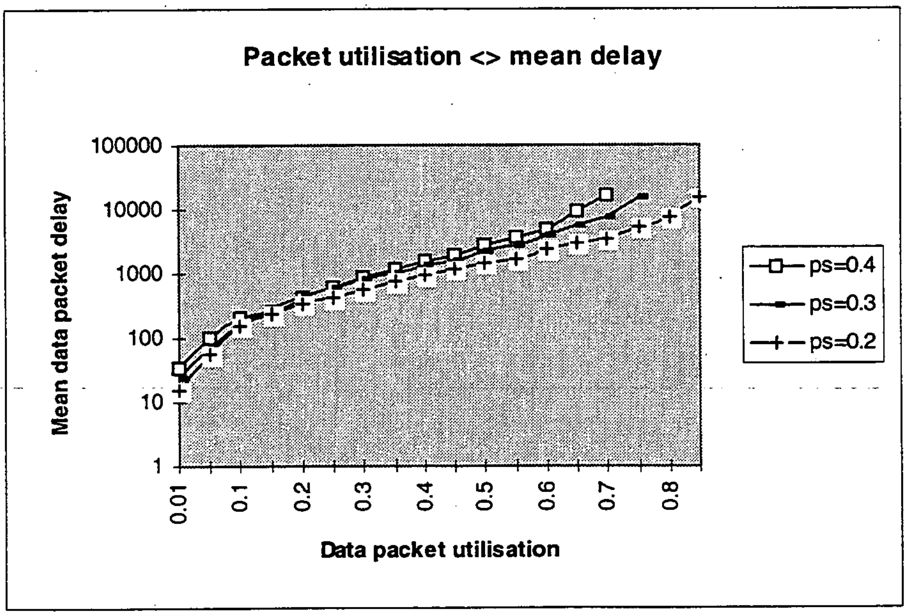


Figure 4.10 Plot of frequency of data packets with respect to delay
Utilisation of the server $\rho = 0.992$
Total number of packets (entered the queue) = 3673479
Mean weighting time = 135000 bits
Worst 5% delay $\approx$ 430000 bits

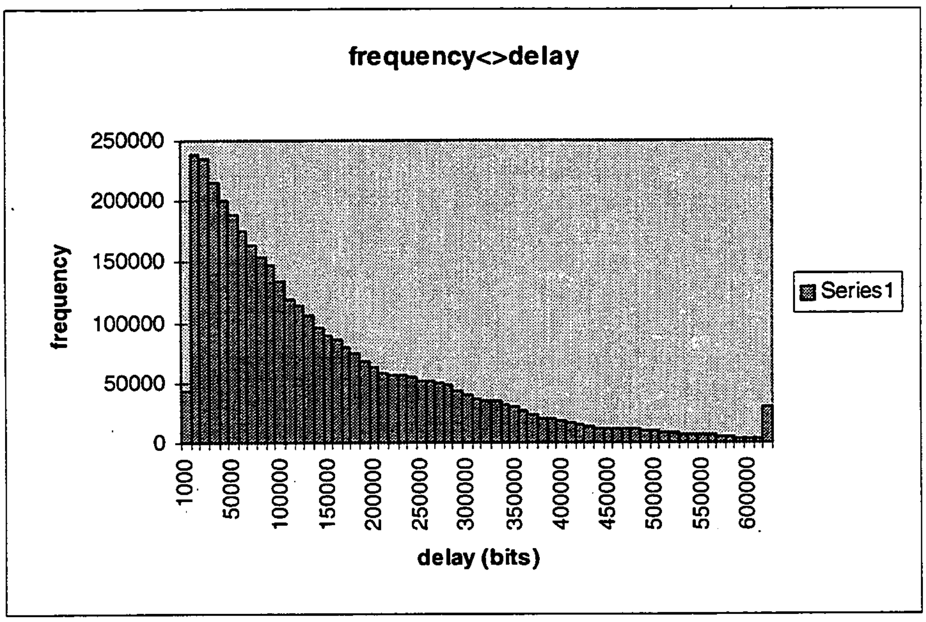


Figure 5.11 Plot of frequency of data packets with respect to delay
Utilisation of the server $\rho = 0.6$
Total number of packets (entered the queue) = 563069
Mean weighting time = 1096 bits
Worst 5% delay $\approx$ 2000 bits

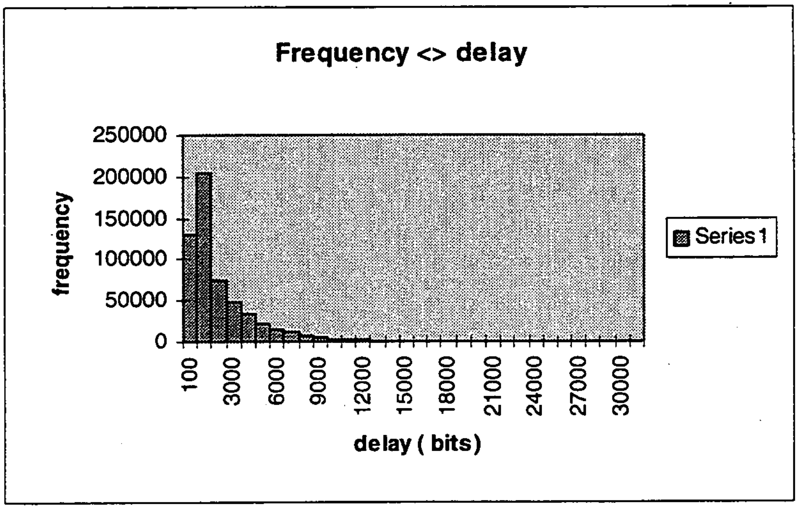
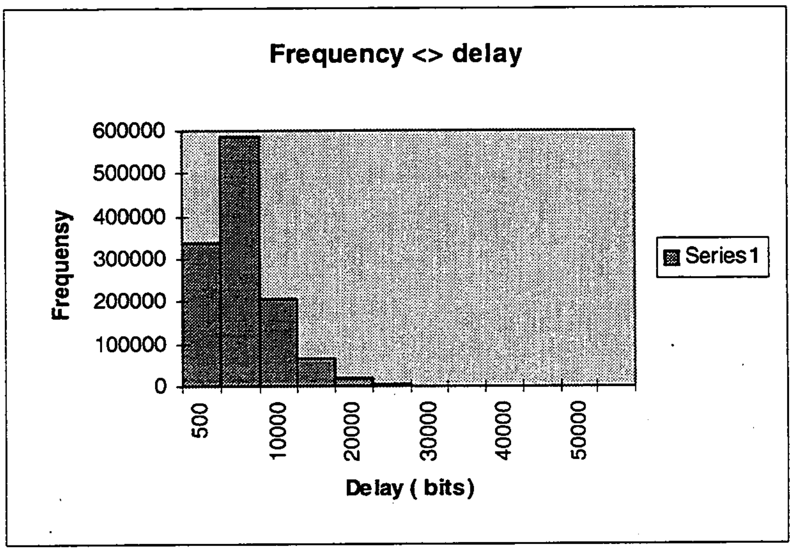


Figure 5.10 Plot of frequency of data packets with respect to delay
Utilisation of the server $\rho = 0.75$
Total number of packets (entered the queue) = 1228677
Mean weighting time = 2600 bits
Worst 5% delay $\approx$ 17500 bits



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